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REPORT ON POLLUTION OF THE INTERSTATE WATERS OF THE MENOMINEE AND BRULE RIVERS, MICHIGAN-WISCONSIN

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Cincinnati, Ohio

November 1963

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REPORT ON POLLUTION OF THE INTERSTATE WATERS OF THE MENOMINEE AND BRULE RIVERS

MICHIGAN - WISCONSIN

By
A. W. West, Public Health Engineer
K. M. Mackenthun, Biologist
L. E. Keup, Biologist
F. W. Kittrell, In Charge
Pollution Evaluation Unit

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

PUBLIC HEALTH SERVICE

ROBERT A. TAFT SANITARY ENGINEERING CENTER

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SUMMARY AND CONCLUSIONS

The Michigan Water Resources Commission and the Wisconsin Committee on Water Pollution pursue active programs to eliminate pollution in the Menominee and Brule Rivers. Pollution has been reduced by industrial waste control practices and by construction of municipal sewage treatment plants. Compliance with orders by the Wisconsin Committee on Water Pollution should lead to further improvement. The real progress that has been made, however, has not prevented or eliminated pollution of certain reaches of the rivers.

UPPER MENOMINEE RIVER

Organic pollution discharged to the Upper Menominee River reduced the symmetrical mean dissolved oxygen content of the river below the 3.0 mg/l level considered critical for fish life by the State of Wisconsin. Minimum values observed during August, 1963 at each sampling station fell to 2.3 at the Norway power dam 8 miles below Niagara and 1.2 mg/l at Faithorn, Michigan, some 15 miles below Niagara. At each of these two sampling stations all samples contained less than 5 mg/l and 6 out of 10 of the samples contained less than 3 mg/l.

Solids pollution, including wood chips and fibers, bacterial slimes, and floating scum and septic sludge, degraded the appearance of the river and reduced its aesthetic appeal for general recreational

use. Solids settled to form sludge deposits which prevent the use of this area for fish spawning and decrease the population of pollution sensitive fish food organisms for some 22 miles below Niagara, Wisconsin.

The Kimberly-Clark pulp and paper mill in Niagara, Wisconsin is the principal source of organic and solids pollution.

For a distance of 14 miles below Niagara, Wisconsin and 9 miles below the mouth of Sewer Creek, the Upper Menominee River contains more than the 5,000 MPN/100 ml total coliform level considered satisfactory for general recreational use. The symmetrical mean density reached 43,500 MPN per 100 ml at the Norway power dam located below Niagara and Norway.

Waste from undetermined sources in Niagara, Wisconsin, effluent from the Niagara, Wisconsin sewage treatment plant and untreated sewage from Norway, Michigan are principal sources of bacterial pollution. The proportionate load from each of these sources was not determined.

The Upper Menominee River also shows evidence of degradation by sludge deposits, producing large populations of pollution tolerant organisms and limiting the development of sensitive bottom forms in the quiet water areas extending from the Iron Mountain-Kingsford sewage treatment outfall to the neck of the impoundment above Upper Quinnesec Dam.

LOWER MENOMINEE RIVER

The Lower Menominee River is degraded for a distance of 3 miles below the Scott Paper Company, at Marinette, Wisconsin, to its mouth by wood chips and fibers, slime bacteria, and the elimination of bottom organisms. This pollution adversely affected the physical appearance of the river and reduced its aesthetic appeal for general recreational use. The Scott pulp and paper mills in Marinette, Wisconsin and Menominee, Michigan are principal sources of pollution above the Marathon Paper Company. Solids from the Marathon Paper Company contribute to pollution at the mouth of the river.

The mean total coliform density of the Lower Menominee River was increased to 8,500 MPN/100 ml, slightly higher than the 5,000 level considered satisfactory for general recreational use. Effluent from the Marinette, Wisconsin sewage treatment plant is the principal source of bacterial pollution in the Lower Menominee River.

BRULE RIVER

Bacterial pollution in the Iron River, which contains treated sewage from the neighboring communities of Iron River, Stambaugh, Caspian and Gaastra, Michigan, increased the total coliform density of the interstate Brule River waters above the 5,000 MPN/100 ml level considered satisfactory for general recreational use for a distance of more than 5 miles, and most probably 8 miles, below the mouth of the Iron River. The symmetrical mean total coliform density increased from 395 MPN/100 ml above the Iron River to 14,200 MPN/100 ml at the sampling station 5 miles below the mouth of the Iron River. The proportionate amount of this

coliform load discharged by each one of the four communities located on the Iron River has not been determined.

For approximately 14 miles, gravel areas on the bottom of the river are cemented together with iron deposits which drastically reduce desirable fish food organisms and interfere with fish spawning. Although much of the damage was done by gross iron pollution which was discontinued in 1963, further investigations will be needed to determine whether or not the present iron mine drainage continues to degrade the river bottom.

Pollution of the Menominee and Brule River is evident. Pollution originating in Michigan and Wisconsin damaged the water quality of the Michigan and Wisconsin waters of these interstate rivers. Pollution, endangering the health and welfare of persons in a state other than in which the pollution originates, is subject to abatement under the Federal Water Pollution Control Act.

BACKGROUND

On the basis of reports, surveys, and studies the Secretary of Health, Education and Welfare having reason to believe that pollution of the Brule and Menominee Rivers in Michigan and Wisconsin is endangering the health or welfare of persons in both States, called a Conference in Menominee, Michigan, for November 6, 1963.

This report prepared for this Conference is based on data and information assembled through the cooperation of numerous Federal, State and local agencies, communities and industries in Michigan and Wisconsin, and on additional data obtained in the field during July 30 through August 16, 1963. Field data were collected by the staffs of the Technical Advisory and Investigations Section, Technical Services Branch, and the Great Lakes-Illinois River Basin Project, U. S. Public Health Service.

The invaluable assistance of the cooperating groups that provided background data and information essential to this report is gratefully acknowledged.

THE AREA

This report is concerned with the reach of the Brule River which serves as a boundary between Michigan and Wisconsin; the Menominee River, which is a boundary stream throughout its entire length; and those tributaries of both streams that carry wastes which contribute to pollution of the interstate waters.

The Brule River (Figure 1) rises in northern Wisconsin near the eastern edge of a popular recreational area which is dotted with innumerable natural lakes. The river flows through Wisconsin in an easterly direction to a point near Nelma, Wisconsin, where it becomes the boundary between Michigan and Wisconsin. About 40 miles downstream from this point the Brule joins the Michigamme River, flowing from the north in Michigan, to form the Menominee River near Florence, Wisconsin. The Menominee River continues as the state boundary flowing in a southeasterly direction for about 115 miles to the Menominee, Michigan-Marinette, Wisconsin area, where it enters the Green Bay arm of Lake Michigan.

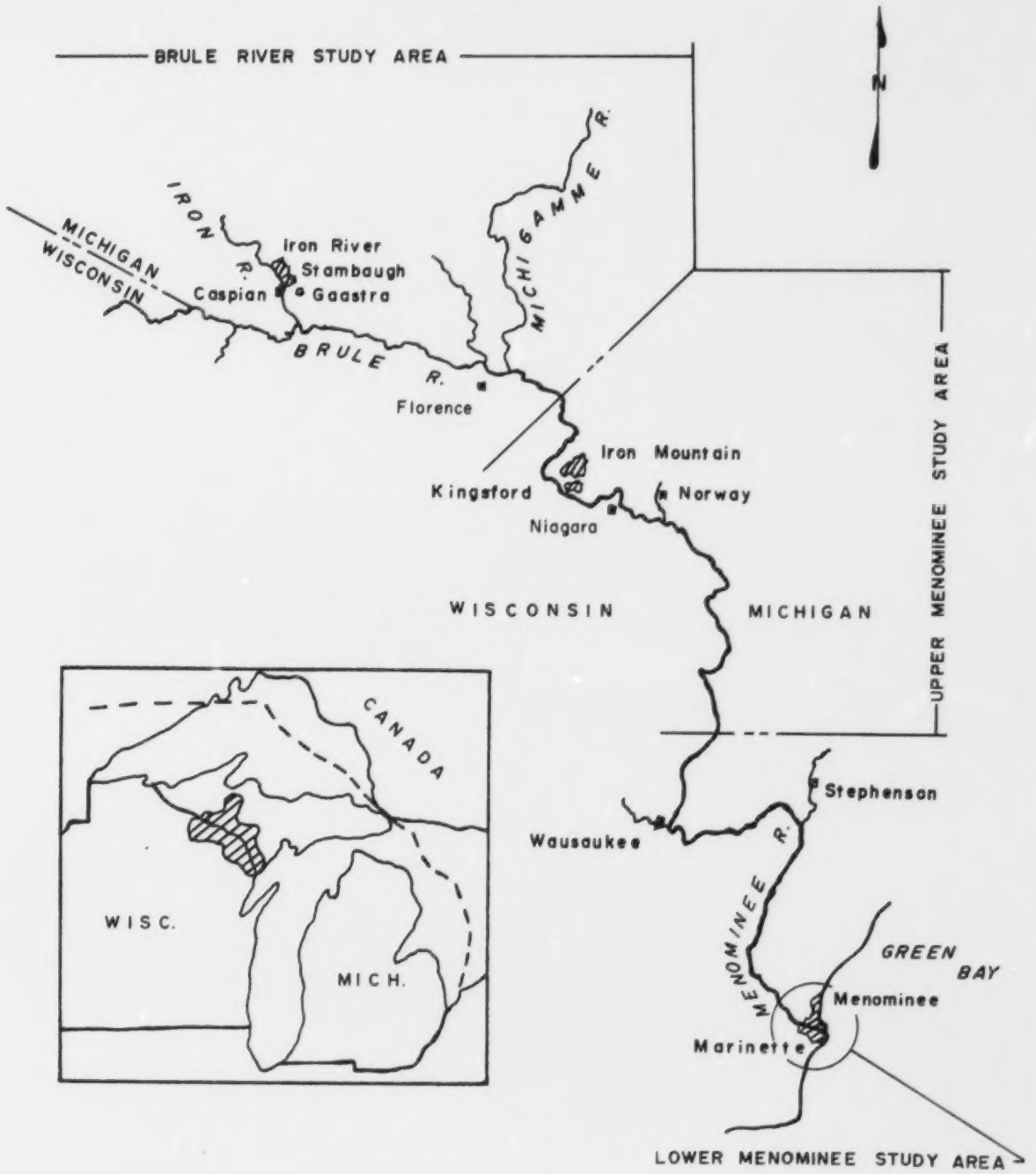
The Brule and Menominee Rivers pass through a gently rolling, thickly wooded valley which exhibits a restful scenic beauty. The virgin white pine forests of the valley, which once provided a major national source of white pine lumber, have largely been replaced by the attractive quaking aspen, interspaced with groups of a variety of conifers and an occasional hardwood.

LOCATION MAP

MENOMINEE RIVER

WISCONSIN — MICHIGAN

FIGURE 1



The wooded expanses are broken only occasionally by towns, small communities and farms.

Important industrial operations occur in the Iron Mountain-Kingsford, Michigan, Niagara, Wisconsin, and Marinette-Menominee areas. Iron ore, pulp and paper, and organic chemicals are the major industrial products.

The dark waters of the Brule and Menominee rivers derive natural color from the swampy areas drained by these streams and their tributaries. Both streams tumble over numerous rapids and eleven dams on the Menominee River, taking advantage of the steep slope of the stream for production of hydroelectric power. There also are a few dams on major tributaries.

The two interstate streams and their tributaries constitute the major surface water resource of the valley. This resource is an essential supplement to the natural beauty and cool summer temperatures of the valley if its full recreational potential is to be realized in competition with that of the adjacent area to the west where natural lakes abound.

WATER USES

The Brule and Menominee Rivers provide opportunity for a variety of water uses.

MUNICIPAL WATER SUPPLY

No municipal water supply is taken directly from either the Brule or the Menominee Rivers.

Green Bay serves as the source of municipal water supply for Menominee, Michigan, and for Marinette, Wisconsin. The intakes for both supplies are located offshore from Menominee, north of the mouth of the Menominee River. The river water usually moves toward the south after entering Green Bay. Despite considerable construction cost, the Marinette intake line was carried beneath the Menominee River and out into the lake north of the mouth of the river in an effort to obtain lake water in preference to a mixture of lake and river water.

There are times, however, when lake currents reverse and carry Menominee River water toward the north and to both the Menominee and the Marinette intakes. At such times the presence of the river water is reflected in the need for increased dosages of water treatment chemicals.

These two supplies furnish water to about 25,000 persons for domestic use.

INDUSTRIAL WATER SUPPLY

Water for industrial processes is taken from the Menominee River by the Kimberly-Clark Corporation at Niagara, Wisconsin, the Scott Paper Company at Marinette, Wisconsin, and the Scott Paper Company and the Marathon Division of American Can Company at Menominee, Michigan.

The combined total use of river water by these plants is about 18.0 million gallons per day.

HYDROELECTRIC POWER

Between Florence, Wisconsin, and the Menominee-Marinette area there are eleven dams which impound run-of-the-river pools on the Menominee River. One of these, at Kremlin Falls, has been abandoned. One is operated to produce power for the town of Norway, Michigan, one to produce power for the Kimberly-Clark pulp and paper mill, two to power the Scott pulp and paper mills at Marinette, Wisconsin and at Menominee, Michigan, and others to produce power for sale by the Wisconsin-Michigan Power Company and the Wisconsin Public Service Corporation.

None of the dams includes facilities for the passage of migratory fish. The quiet pools above some of the dams enhance the recreational potential of the river.

RECREATION

The Brule and Menominee rivers are suitable for various recreational uses. The full recreational potential of the rivers has not yet been realized.

Fishing

Fishing probably is the major present recreational use of the waters of the two rivers.

The cool, swift waters of the upper reaches of the Brule River provide an ideal habitat for trout, and there are numerous trout fishing enthusiasts in the area.

The warmer waters of the Menominee are not generally suitable for trout, but do support sturgeon, walleye, bass, crappie, blue gill, and other sport as well as rough fish. Sport fishermen use the river at accessible intervals along its length; the greatest use is in the Marinette-Menominee area.

Boating

Because of swift, shallow rapids, some reaches of the river are suitable only for canoeing. There is some use of the pools above the power dams by outboard motor boats. Here again, major power boat use is in the Marinette-Menominee area, where a large boat docking and service area is available. Many of the boats at this marina are large lake-going vessels.

Swimming

The water of the Brule River is too cool to encourage swimming, and there are no known beaches on the Menominee. Where water is suitable, however, there will be some swimming by individuals on an unorganized basis, and the Menominee undoubtedly is no exception.

There are five beaches for organized swimming along the lake front in the Menominee-Marinette area. Water from the Menominee River undoubtedly reaches all of these beaches at times.

WASTE DISCHARGES

MAJOR AREAS

Upper Menominee River

Near the upper end of the Menominee River, Iron Mountain, Kingsford and Norway, Michigan and Niagara, Wisconsin, discharge sewage. All except Norway, which has no plans for sewage treatment, discharge treated sewage directly to the Menominee. Norway discharges raw sewage to Sewer Creek about three miles from the river. The Kimberly-Clark Corporation discharges residual sulfite and ground-wood pulp and paper mill wastes to the Menominee River at Niagara.

Lower Menominee River

Near the mouth of the Menominee River, Marinette, Wisconsin and Menominee, Michigan discharge treated sewage to the river. In Marinette, the Scott Paper Company discharges residual sulfite pulp and paper mill wastes and the Ansul Chemical Company discharges wastes from the manufacture of organic chemicals. In Menominee the Marathon Division of American Can Corporation discharges paper mill wastes and the Scott Paper Company discharges ground-wood pulp wastes.

Brule River

Four small towns, Iron River, Stambaugh, Caspian, and Gaastra, discharge sewage, after varying degrees of treatment, to the Iron River in the reach from 5 to 8 miles above its junction with the Brule River.

The Homer-Wauseca, Sherwood and Hiawatha #1 and #2 iron mines discharge mine drainage containing acid, iron and silt to the Iron River. Florence, Wisconsin discharges treated sewage near the mouth of the Brule.

MINOR AREAS

Other sources of wastes in the valley are small towns and industries situated on tributaries at varying distances from the two interstate streams. One of these, Stephenson, Michigan, presently is discharging raw sewage to Little Cedar River while the old sewage treatment plant is being replaced by construction of a new plant.

Wastes from the White House Milk Company of Stephenson, Michigan receive secondary treatment before being discharged to the Little Cedar River.

Individual septic tanks are used in Wausaukee, Wisconsin and an oxidation pond sewage treatment plant is under construction. The Pauley Cheese Company of Wausaukee discharges wash water to the Wausaukee River, but concentrated whey is collected and returned to the farmers.

The high purification rates of the tributaries prevent contributions of several minor waste sources from having any pollutional effect on the interstate waters. There are problems of local, intrastate pollution for which corrective measures are needed.

CONTROL ACTIVITIES OF STATE AGENCIES

The Michigan Water Resources Commission and the Wisconsin Committee on Water Pollution adopted a joint resolution concerning waste treatment requirements for the Brule and Menominee Rivers and tributaries in 1954. The resolution provided that sewage should be treated by at least effective sedimentation and disinfection with higher degree of treatment, if necessary. Industrial wastes should be treated to the degree warranted in each case. The two State water pollutional control agencies have worked with municipalities and industries to accomplish the objectives of the joint resolution.

Iron Mountain, Kingsford and Menominee provide primary treatment with two-stage, pre- and post-chlorination. Niagara and Marinette provide primary treatment with single stage chlorination. Stambaugh provides secondary treatment with single stage post chlorination. Florence, Wisconsin does not provide chlorination, but has a sewage stabilization pond which accomplishes significant bacterial reduction. Caspian and Gaastra, Michigan have inadequate sedimentation facilities and do not provide chlorination. Norway, Michigan has a sewerage system but does not provide sewage treatment. Iron River, Iron Mountain, Kingsford and Norway, Michigan, and Florence and Marinette, Wisconsin, have combined sewers, and Menominee, Michigan and Niagara, Wisconsin have partially combined and partially separate sewer systems. During storms, raw sewage without primary treatment or chlorination may escape from the combined sewers to adjacent water courses. The Wisconsin State Committee on Water Pollution, in February, 1963, ordered Niagara to develop a plan for separation of storm and sanitary sewers by July 1, 1964.

Stephenson, Michigan is building a new sewage treatment plant.

The iron mines, with the exception of Hiawatha #1, provide lagoons which settle portions of the silt and insoluble iron. The Homer-Wauseca mine formerly was the major source of acid mine drainage pollution in this area. This problem has been reduced by diverting fresh water away from the mine and discontinuing the pumping of acid iron bearing waters from the mine shaft.

The Kimberly-Clark Corporation at Niagara provides facilities for fiber recovery, and hauls portions of sulfite waste liquor for use as road binder. During periods of low stream flow additional sulfite waste liquor is disposed of by spray irrigation. In 1954, the Wisconsin State Committee on Water Pollution ordered this company to submit satisfactory plans for reducing sulfite waste liquor by March 31, 1955, and to complete construction of facilities by December 31, 1955. In February, 1963, the Committee ordered the company to submit plans for additional reduction of pollutional matter discharged from the pulp mill by July 1, 1964.

At Marinette, Wisconsin, the Scott Paper Company provides facilities for fiber recovery, and disposes of a portion of the sulfite waste liquor for use as a road binder. In February, 1963, the Wisconsin State Committee on Water Pollution ordered the company to submit plans for additional reduction in wastes by July 1, 1964. Several years ago acid wastes from the Ansul Chemical Company caused gross pollution of the Menominee, but discontinuance of the manufacturing process that produced the acid has eliminated the problem.

In Menominee, Michigan, the Scott Paper Company plant provides facilities for fiber recovery. The Marathon Plant also provides facilities for fiber recovery, and for recovery of wax, which formerly caused a pollution problem.

Federally Aided Sewage Treatment Facilities

Located within the Menominee River interstate area are seven sewage treatment projects which have received construction grant aid under the Federal Water Pollution Control Act. Four of these projects have been completed, and two are presently under construction. The latest project is in the final stage of preparation prior to the start of construction. These projects comprise a total eligible cost of $1,114,303.00, which includes $347,783.00 of Federal grants. Table 1 displays a summary of information relative to each of these projects.

RIVER DISCHARGE AND DROUGHT FLOW RECORDS

Summer rainfall in this area was the lowest experienced for many years. Water withdrawn from storage behind the power dams supplemented discharges in the Menominee River. During the twelve days of the August 5-16, 1963 survey, the mean daily river discharges averaged 48 cubic feet per second (cfs) in the Iron River and 300 cfs at the mouth of the Brule. The Menominee River discharges averaged 1200 cfs in the Niagara area, 1330 cfs at Chalk Hill Dam (river mile M-56.6), and 1400 cfs at the Grand Rapids Dam some 25 miles above Marinette.

The critical minimum river discharges that can be expected in this area are published in the "Drought Flow of Michigan Streams" developed by the Department of Environmental Health, School of Public

TABLE 1

FEDERALLY-AIDED SEWAGE TREATMENT FACILITIES WITHIN THE MENOMINEE RIVER INTERSTATE AREA

MUNICIPALITY	COUNTY	DATE OF OFFER	AMOUNT OF GRANT	ELIGIBLE PROJECT COST	TYPE OF PROJECT	STATUS
MICHIGAN						
Iron Mountain-Kingsford	Dickinson	6-11-59	135,600	467,512	Primary with chlorination	Completed 11-4-60 - WPC
Iron River	Iron	11-29-57	58,940	196,468	Primary with chlorination	Completed 11-5-59 - WPC
Iron River	Iron	10- 8-63	6,250	12,500	Interceptor	Plans and specifications under preparation - APW
Stambaugh	Iron	11-15-57	58,048	199,288	Interceptor and Activated Sludge	Completed 11-18-58 - WPC
Stephenson	Menominee	1- 7-63	46,200	114,800	(Additions) Trickling filter with chlorination	Under construction - APW
WISCONSIN						
Florence	Florence	10-18-57	16,395	55,335	Stabilization pond	Completed 11-6-59 - WPC
Wausaukee	Marinette	1- 9-63	26,350	68,400	Stabilization pond	Under construction - APW

Health, University of Michigan, in cooperation with Michigan Water Resources Commission. Following is a comparison of the projected drought flows with the twelve day average Menominee River discharges that occurred near Iron Mountain and above Marinette during the survey.

Menominee River at Twin Falls Dam - Near Iron Mountain, Michigan (M-105.5)

Drought flow records indicate that a minimum twelve day average flow of 975 cfs can be expected during some period each year. Once every five years this minimum twelve day average could drop to 700 cfs and it could fall as low as 590 cfs once every ten years.

The 1130 cfs average discharge observed at this station during the survey is slightly greater than the drought flow that can normally be expected once each year.

Menominee River at Grand Rapids Dam - Below Koss, Michigan (M-24.7)

Drought flow projections show that minimum twelve day average discharges can be expected to fall to 1620 cfs each year, to 950 cfs once every five years, and to 720 cfs once every ten years.

At this station, the observed 1412 cfs average discharge was 13 percent less than the most probable annual minimum drought flow. The records indicate that flow rates prevailing during the survey can be expected to recur once every two or three years.

Design Criterion

The minimum seven day average river discharge that will most probably occur once every ten years is a commonly accepted design criterion for pollution abatement work. Pollution abatement facilities should therefore be capable of reducing pollution loads to levels that can be discharged into the Menominee River system without damaging the water resources during critical periods when the river discharge is considerably lower than the flows that prevailed during the August 1963 survey.

UPPER MENOMINEE RIVER

SOURCES OF WASTES

Wastes from a pulp and paper mill, effluents from two sewage treatment plants and raw sewage from a third community enter the Upper Menominee River. Locations of these discharges are shown on Figure 2.

The estimated organic and solids waste loads are posted on Table 2 and illustrated on Figures 3 and 4. Organic pollution was measured by the five-day Biochemical Oxygen Demand test (BOD) which is a measure of the dissolved oxygen used by organic matter in water. The results of the BOD test are expressed in population equivalents (PE) with one population equivalent equal to 0.167 pounds of 5-day BOD per day.

Approximately 305,000 PE, amounting to 96 percent of the total 317,000 PE of organic wastes entering the Upper Menominee River was discharged by the Kimberly-Clark Corporation pulp and paper mill in Niagara, Wisconsin. Effluents from the Iron Mountain-Kingsford and Niagara treatment plants, and raw sewage from Norway contributed the remaining 4 percent of the organic load.

Approximately 10 tons per day of volatile suspended solids, amounting to 96 percent of the total 10-1/2 tons per day, was discharged by the Kimberly-Clark mill. The other 4 percent was discharged by the three previously named communities.

UPPER MENOMINEE RIVER

LOCATION MAP

FIGURE 2

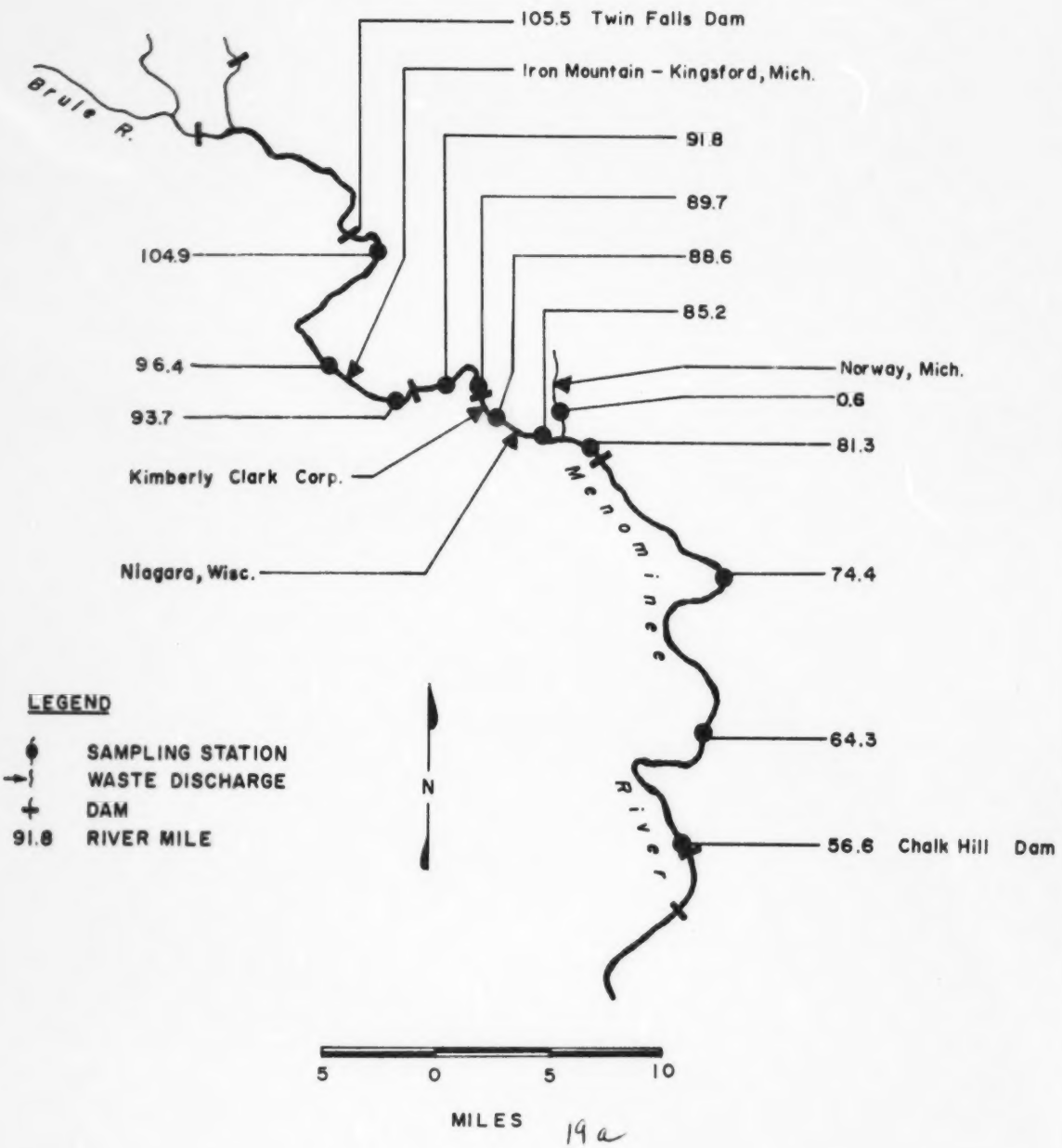


TABLE 2

SOURCES OF WASTES

Estimated Net Loads to Upper Menominee River

August, 1963

SOURCE	ORGANIC WASTES (5-Day BOD)		SOLIDS WASTES (Vol. Susp. Solids)	
	Population Equivalents	% of Total	Tons/ Day	% of Total
Iron Mountain-Kingsford, Michigan(1) (Primary Treatment with pre- and post-chlorination)	9,800	3.1	0.2	2
Kimberly-Clark Corp.(2) Niagara, Wisconsin (Fiber recovery, spray irrigation, and hauling for road binder)	304,800	96.1	10.1	96
Niagara, Wisconsin(3) (Primary Treatment with prechlorination)	1,500	0.5	0.1	1
Norway, Michigan(4) (No Treatment - raw sewage discharged to Sewer Creek)	840	0.3	0.1	1
TOTAL -	316,940	100.0	10.5	100

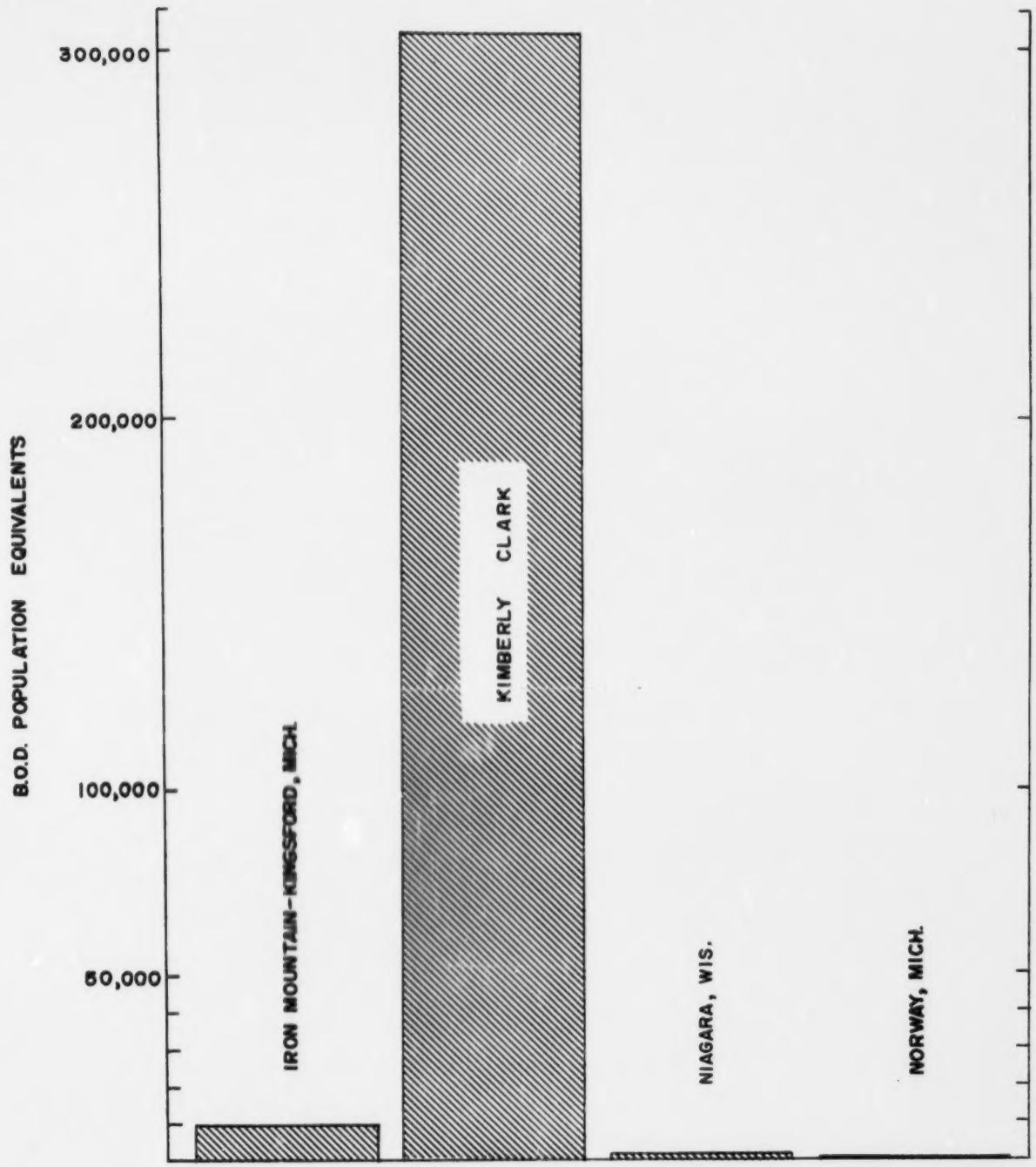
(1) Data from Sewage Treatment Plant operating reports.
(2) Calculated from basic data provided by Kimberly-Clark Corporation.
(3) P.E. from 1963 rough draft for Revised 1960 Summary Report. Solids calculated from P.E. estimate and average reductions.
(4) Calculations based on samples collected from Sewer Creek near mouth.

SOURCES OF WASTES

B.O.D. POPULATION EQUIVALENTS

UPPER MENOMINEE RIVER

FIGURE 3

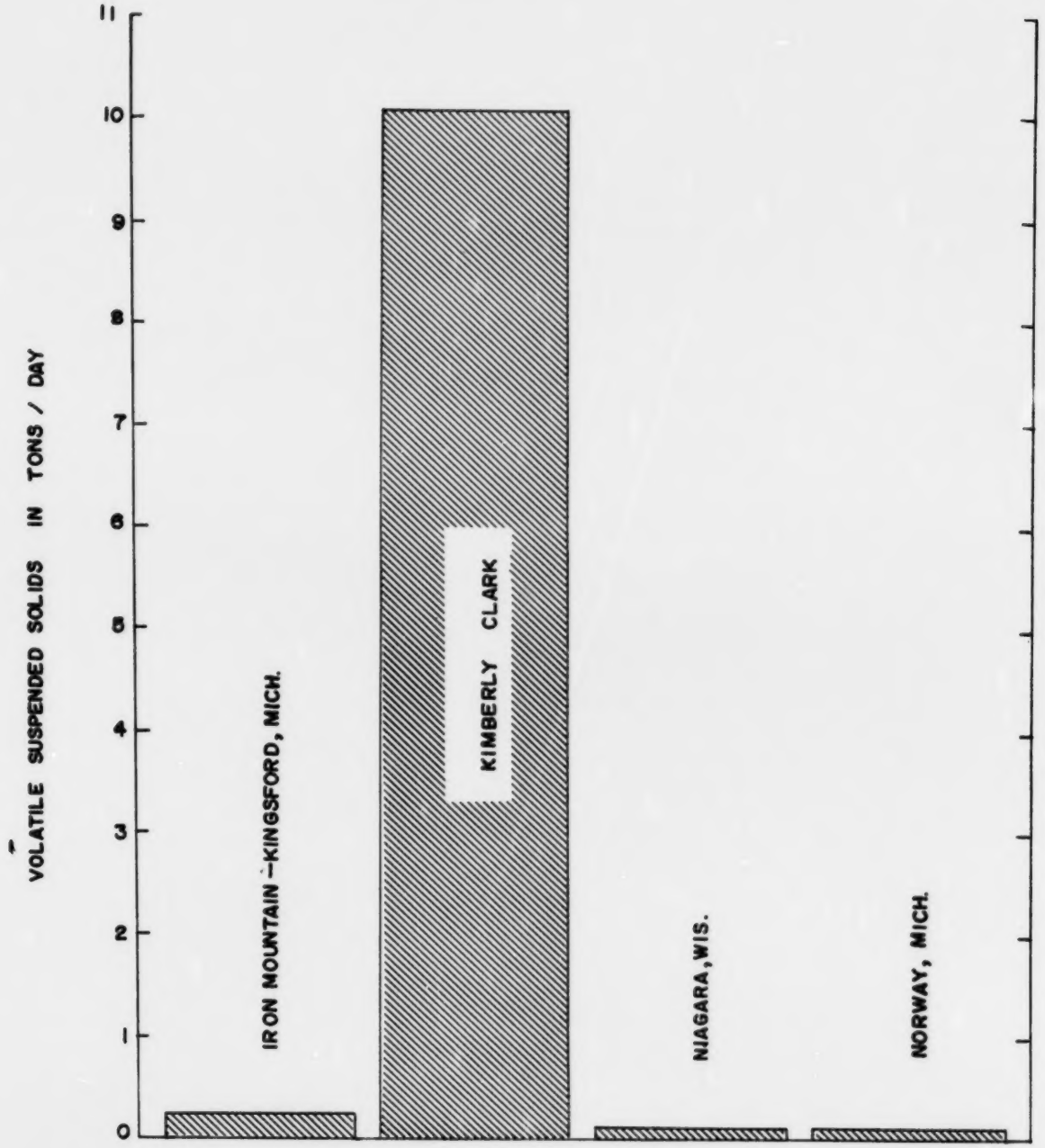


SOURCES OF WASTES

VOLATILE SUSPENDED SOLIDS

UPPER MENOMINEE RIVER

FIGURE 4



EFFECTS ON WATER QUALITY

5-day Biochemical Oxygen Demand (BOD)

Figure 5 shows that the BOD of the Menominee River, averaging 1.1 mg/l above Kimberly-Clark, increased to 16.8 mg/l in the waste stream along the Wisconsin side of the river about one mile below the paper mill. At the U. S. Highway 8 bridge (M-85.2), 4-1/2 miles below the mill, the wastes were mixed throughout the Michigan and Wisconsin waters across the entire river and the BOD averaged 5.0 mg/l. Natural purification reduced the BOD throughout the thirty-three mile reach to Chalk Hills Dam, (M-56.6), where it reached the level of 1.5 mg/l. The effect of this biochemical oxygen demand on the river is discussed in the next section on dissolved oxygen.

Dissolved Oxygen (DO)

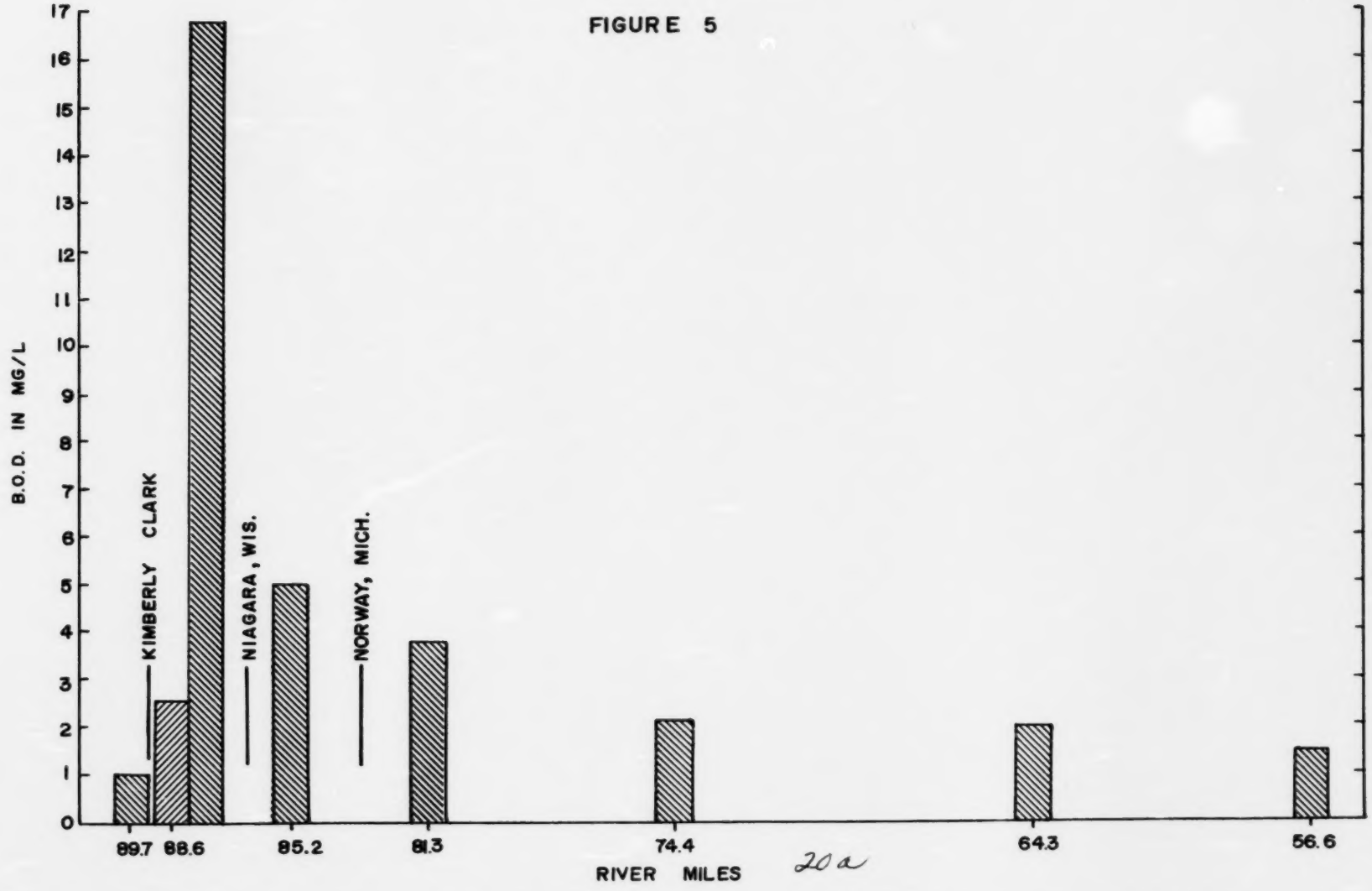
For sustained propagation of a normal healthy warm water game fish population, fresh water rivers and lakes should contain at least 5.0 mg/l of dissolved oxygen. Although moderate reductions of DO below this level for short periods of time may not injure adult fish, it is generally agreed that the dissolved oxygen concentration should not be reduced below a minimum of 3.0 mg/l at any time.

The review draft of the second edition of "Water Quality Criteria", prepared for the California Water Pollution Control Board, states that: "For fish and other aquatic life, the recommendations of the Aquatic Life Advisory Committee of ORSANCO (as quoted above) appear to be logical." This recommendation is quoted as follows:

B.O.D.

UPPER MENOMINEE RIVER

FIGURE 5



"The Aquatic Life Advisory Committee of ORSANCO (2408) has recommended that the minimum permissible oxygen concentration for a well-rounded warm water fish population be as follows: The dissolved-oxygen content of warm water fish habitats shall be not less than 5 mg/l during at least 16 hours of any 24-hour period. It may be less than 5 mg/l for a period not to exceed 8 hours within any 24-hour period, but at no time shall the oxygen content be less than 3 mg/l. To sustain a coarse fish population, the dissolved-oxygen concentration may be less than 5 mg/l for a period of not more than 8 hours out of any 24-hour period, but at no time shall the concentration be lower than 2 mg/l."

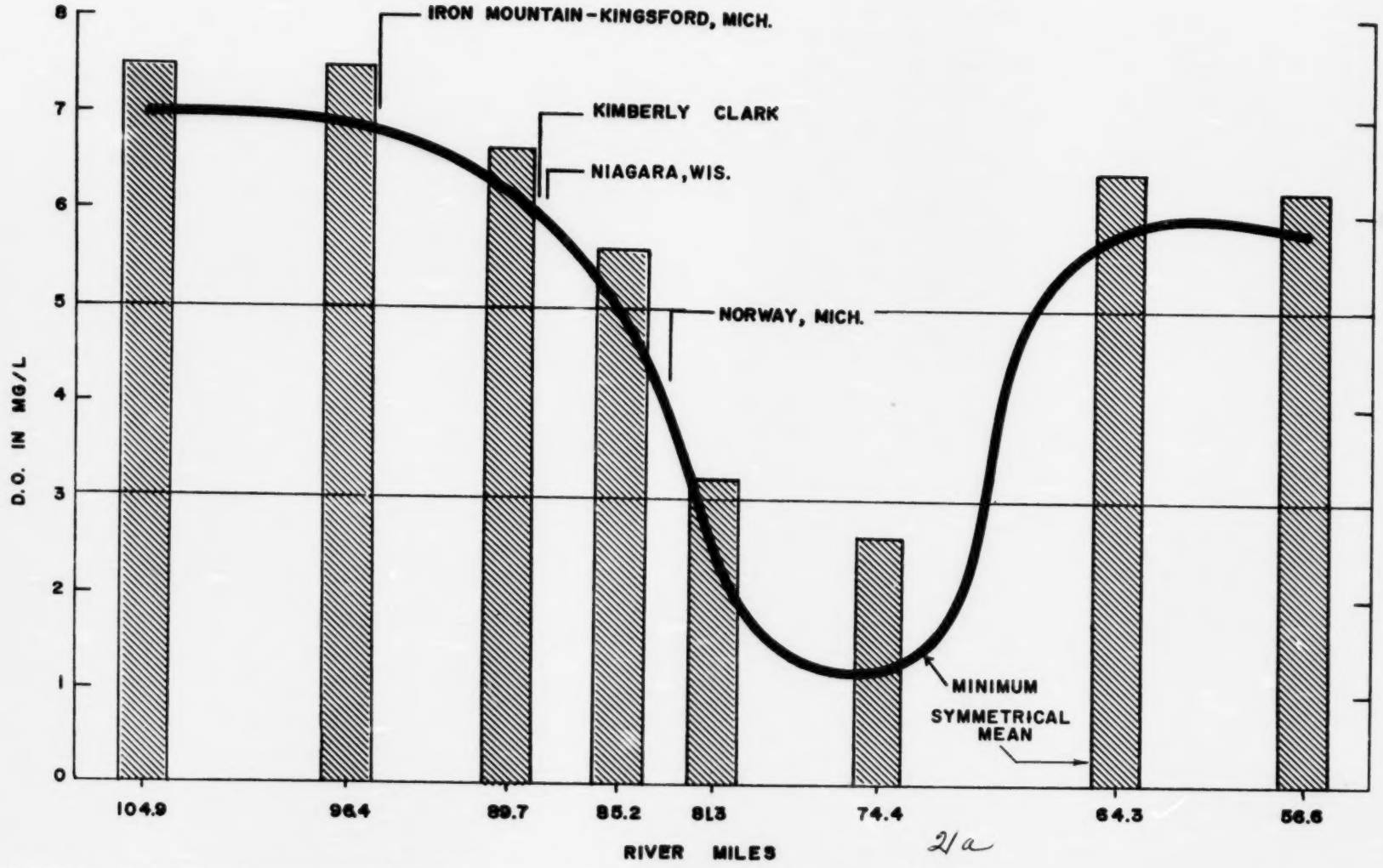
The Wisconsin Committee on Water Pollution defines dissolved oxygen limitations as follows:

> "The Dissolved Oxygen (DO) in parts per million (p.p.m.) is a measure of the amount of oxygen dissolved in water. A saturated solution of dissolved oxygen in water will contain about 14.0 p.p.m. at 0° and about 8.5 p.p.m. at 25°C. Concentrations of less than 5.0 p.p.m. DO interfere with fish propagation and concentrations of less than 3.0 p.p.m. DO are considered critical for fish life."

The extent to which organic pollution lowered the dissolved oxygen concentrations in the Upper Menominee River during the August, 1963 survey is illustrated on the DO chart, Figure 6. The solid line traces minimum observed DO and the bars represent the symmetrical mean of all samples collected at each station.

The symmetrical mean DO's were determined as follows: All DO's observed at each sampling station were arrayed in descending order and

DISSOLVED OXYGEN
UPPER MENOMINEE RIVER
FIGURE 6



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plotted on probability paper. The symmetrical mean DO is the level at which the observed DO trend line crossed the 50 percent time of occurrence line. Thus, the dissolved oxygen concentration in the river was equal to or less than the symmetrical mean DO value 50 percent of the time.

The symmetrical mean dissolved oxygen was reduced from 7.5 mg/l above Kingsford (M-96.4) to 6.6 mg/l above the Kimberly-Clark dam (M-89.7), some 6-1/2 miles downstream from the Iron Mountain-Kingsford Sewage discharge. Water in the impoundment above the Kimberly-Clark dam remained satisfactory, but the dissolved oxygen concentration had decreased 0.9 mg/l. Calculations indicate that only 1/3 of this oxygen reduction or less than 0.3 mg/l, can be attributed to the treated sewage discharge by Iron Mountain-Kingsford. The remainder may be caused by decomposition of the sludge deposits which were observed along the river bottom from Kingsford to the neck of Upper Quinnesec Reservoir.

Wastes from the Kimberly-Clark mill are discharged to the river below the power dam in Niagara. For more than 15 miles below this point the dissolved oxygen was progressively reduced by the decomposition of organic wastes in the river. During the August 1963 survey, the mean dissolved oxygen concentrations fell to 3.2 mg/l at the Norway Power Dam (M-81.3) and to 2.6 mg/l at the railroad bridge near Faithorn, Michigan (M-74.4), some 15 miles below the paper mill sewers. At each of these two stations, all samples contained less than 5 mg/l and 6 out of 10 of the samples contained less than 3 mg/l. Furthermore, the minimum values recorded at these two stations were 2.3 and 1.2 mg/l respectively.

This severe reduction in dissolved oxygen, caused almost entirely by waste discharges from the Kimberly-Clark pulp and paper mill in Niagara,

reduced the Menominee River water quality below the critical level for fish life.

Natural purification in the next 10 mile reach of the river increased the mean dissolved oxygen concentration to 6.4 mg/l at the Wisconsin County Trunk Z sampling station (M-64.3), about 25 miles below the paper mill discharge.

Suspended Solids

From Niagara, Wisconsin down to the Norway power dam, the appearance and aesthetic appeal of the Menominee River suffered greatly from the effects of solids pollution entering the stream. Suspended material, floating down the stream, produced a yellowish turbid appearance and scattered patches of decomposing sludge were observed floating on the surface of the water.

The mass of volatile solids suspended in the river, calculated from data collected during the survey, amounted to 2.3 tons per day above Niagara. About one mile below the pulp and paper mill (M-88.6), the solids content increased sharply to 13 tons per day. Downstream these values tapered off to 7.8 at County Trunk Z (M-64.3), and 4 tons per day in the impoundment above Chalk Hills Dam (M-56.6), some 33 miles below Niagara.

This degraded appearance, caused principally by solids discharged in the paper mill wastes, damaged the recreational potential of this reach of the Menominee River.

BIOLOGY

Past Studies

A report on a biological study conducted July 1 - August 1, 1961, by the Wisconsin Committee on Water Pollution, discussed benthic conditions in the Menominee River from Upper Quinnesec flowage above Niagara, Wisconsin, to Kremlin Falls, approximately 16 miles below Niagara. Above Niagara, the bottom organism community was considered normal for the environment for which the samples were collected. Below Niagara slime bacteria were observed attached to bottom materials and shoreline debris. In the region of Pier's Gorge, pollution tolerant organisms predominated. Just below Sturgeon Falls, 12 varieties of bottom biota were reported, but sensitive organisms were confined to one species of caddisfly larva and a riffle beetle. A return to a normal bottom dwelling population was reported at Kremlin Falls.

Current Biological Data

In the Kingsford-Iron Mountain, Michigan area, samples were taken one-half mile above the sewage treatment plant outfall, one-half mile below the outfall, and again where the river enters Upper Quinnesec reservoir (Figure 7). Above the sewage plant outfall there existed a balanced bottom dwelling community consisting of many sensitive organisms and relatively few very tolerant sludgeworms. These bottom organisms indicate the suitability of the stream at this point for the development of normal stream life, including fish. Some 200 yards below the sewage treatment plant, on the Michigan side, a sample collected from an area

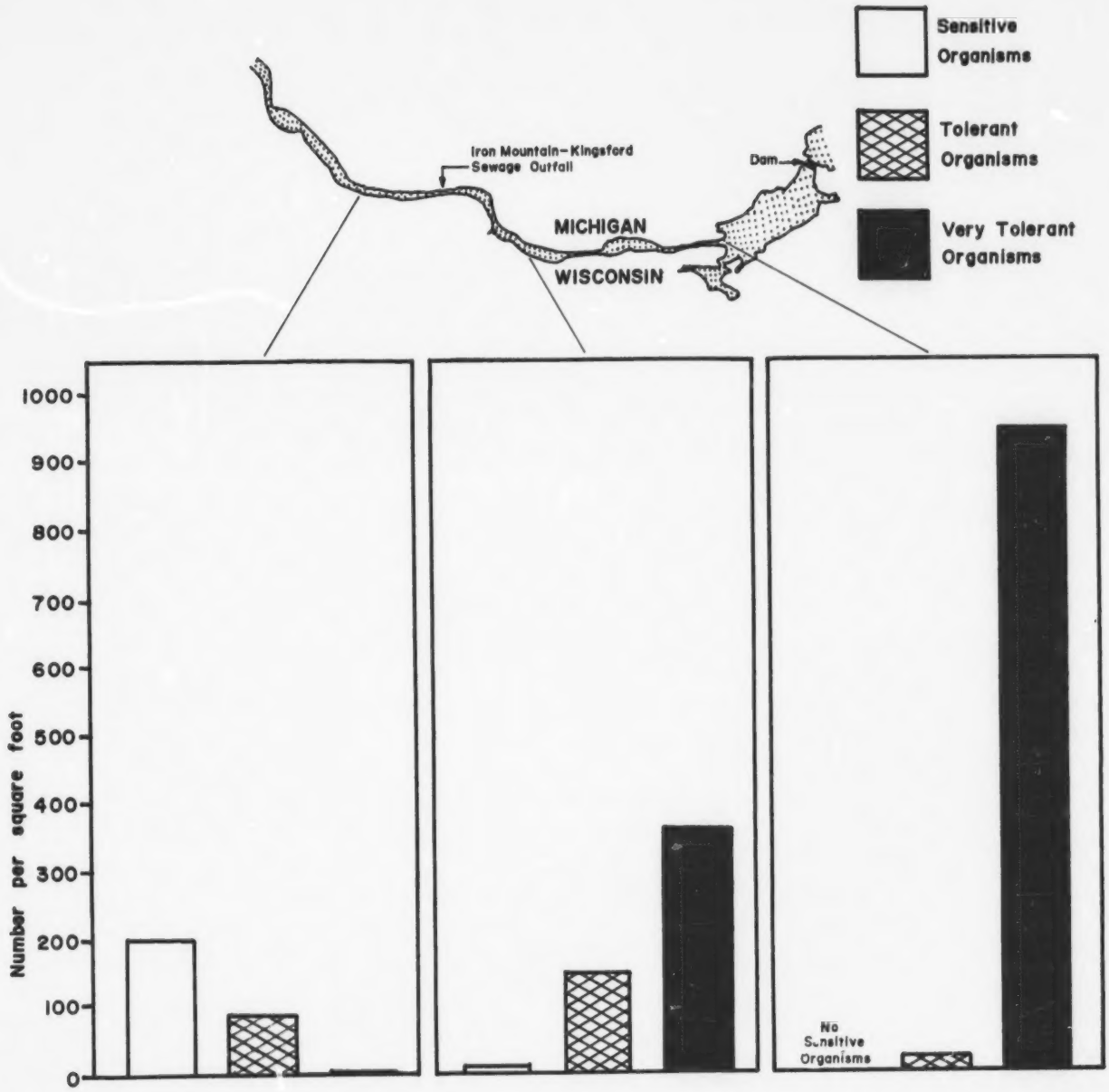
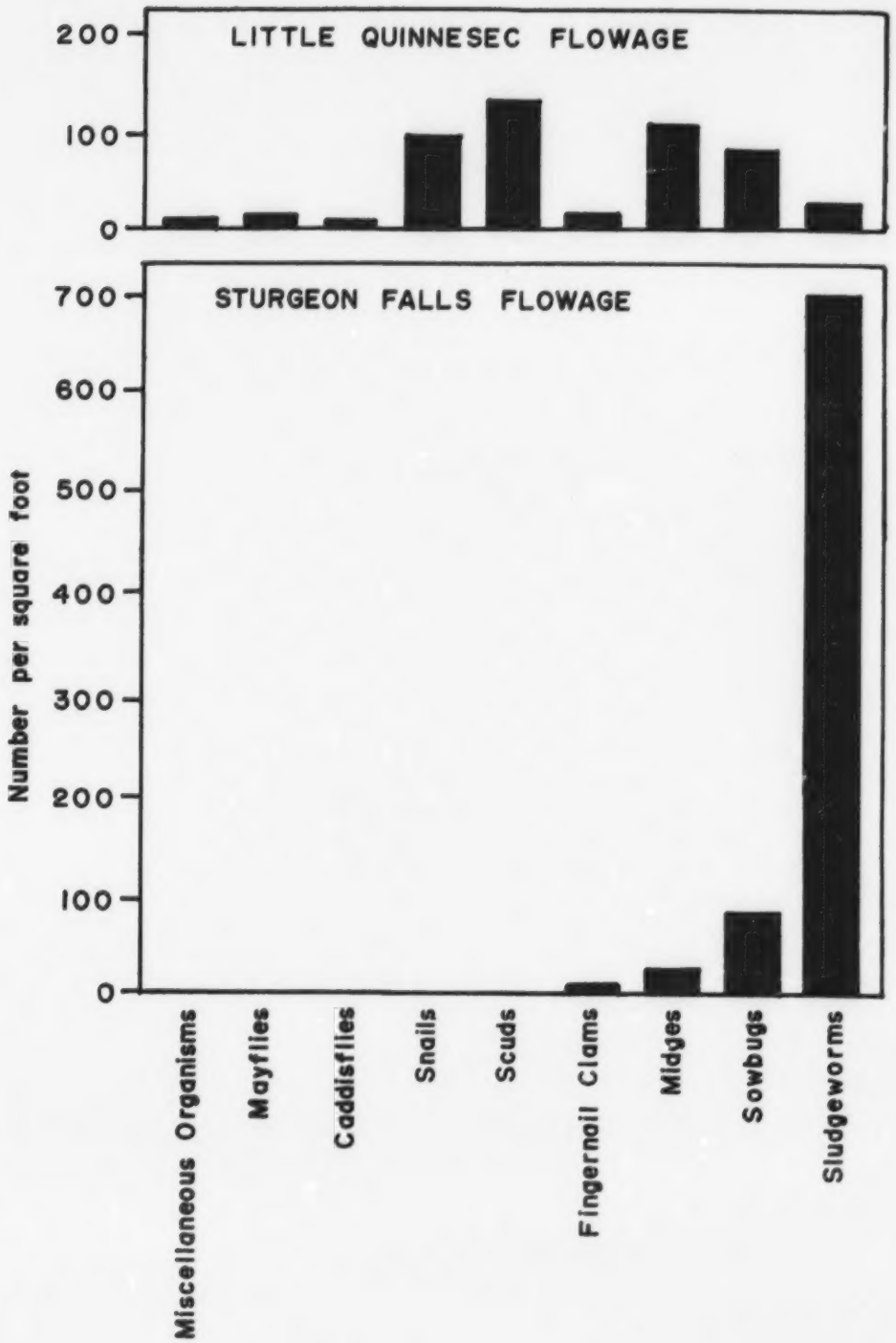


Figure 7 . Bottom organism populations — Iron Mountain-Kingsford area, Menominee River, August, 1963

of sludge deposition revealed only sludgeworms and bloodworms, the former reaching population exceeding 37,000 per square foot. This represents a polluted environment. At the sampling site one-half mile below the outfall, sensitive forms were much reduced compared to the station one mile above and sludgeworms had increased from four per square foot to 335 per square foot. As the river enters Upper Quinnesec reservoir, suspended solids settle, forming a delta around the neck of the reservoir. Samples from this area, collected from 50 feet of water, revealed a sludgeworm population exceeding 950 per square foot and no sensitive organisms, representing a habitat polluted with sludge. These sludge deposits eliminate most fish food that would normally develop on the bottom at this point. The bottom material had a definite sewage odor. Additional samples, collected from the upper end of the reservoir but away from the river channel revealed burrowing mayflies and gill-breathing snails, and a much reduced sludgeworm population, indicating that the polluted habitat is limited to the neck of the reservoir. Bottom conditions where the Menominee River enters Upper Quinnesec reservoir appeared worse during the current survey than during the 1961 Wisconsin survey.

To ascertain the effect of pollution discharged at Niagara, Wisconsin, on sluggish water areas, samples were taken from Little Quinnesec reservoir above Niagara, as well as from the Sturgeon Falls reservoir about one mile above the confluence with the Sturgeon River (Figure 8). The bottom organism population found in the reservoir above Niagara is considered typical for a clean water environment. A great diversity of organisms was found. In the Sturgeon Falls reservoir, below Niagara,

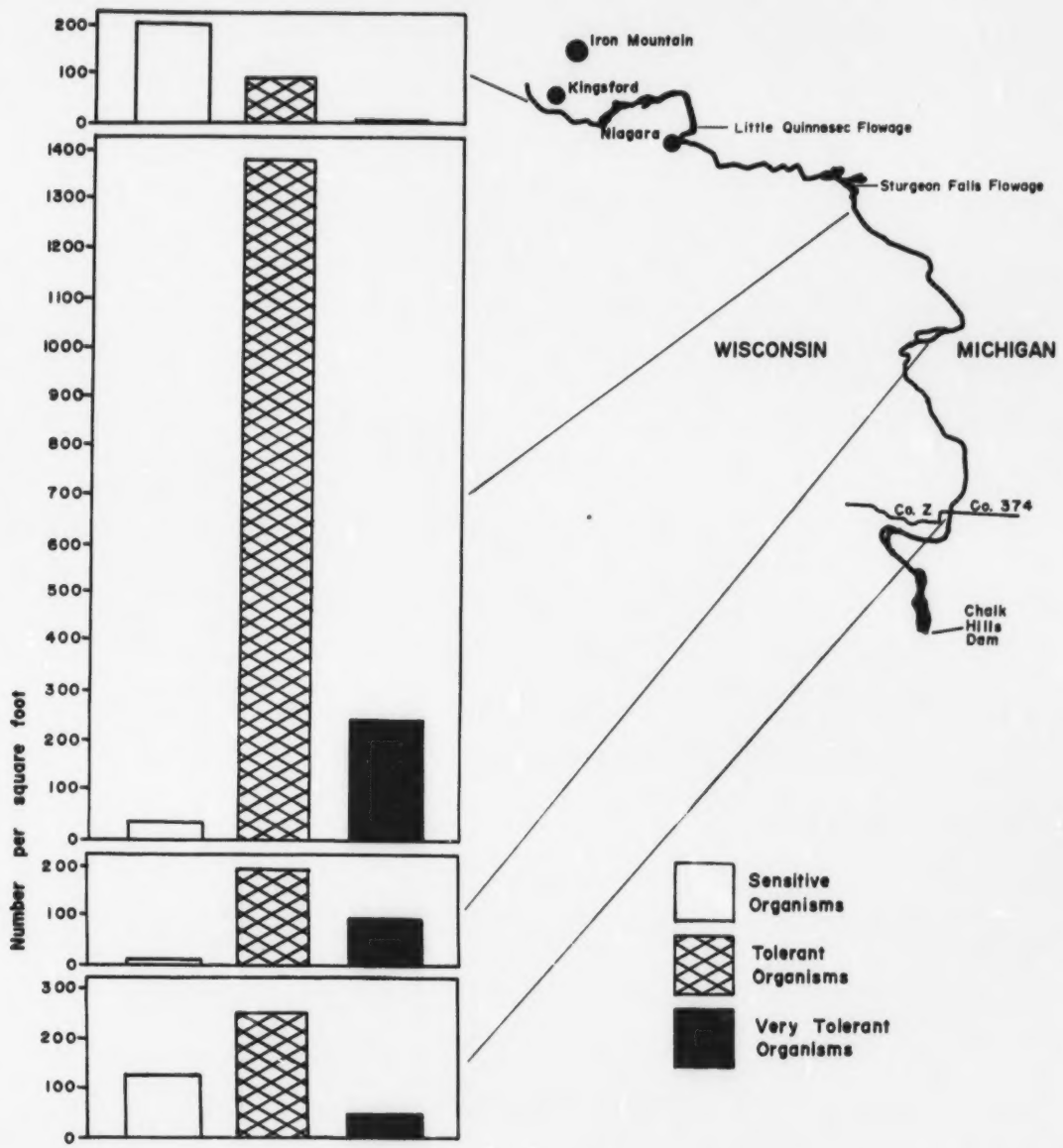
Figure 8. Comparison of bottom organism populations — upper Menominee River flowages, August, 1963.



forms sensitive to pollution were eliminated and the sludgeworm population was drastically increased, indicating degraded bottom conditions by wastes discharged from the Niagara area. The water was definitely turbid; sludge and wood chips were found in areas of reduced current. Wood fibers and limited quantities of slime bacteria were present.

To determine the effect of pollution arising at Niagara on organisms living in flowing water, downstream stations were compared with the flowing clean water area above Kingsford-Iron Mountain, Michigan. One-half mile below the Kimberly-Clark Corporation at Niagara, Wisconsin, slime bacteria and wood chips were observed floating downstream. The river bottom was coated with slime bacteria and fibers, and small balls of sludgeworms entwined themselves in this mass, indicating severe biological degradation. Fish food and fish spawning areas have been destroyed. Just below Pier's Gorge the rock bottom was extremely slick and was covered with a filamentous green algae, wood fibers, and slime bacteria. This substratum supported principally tolerant leeches and isopods with an occasional mayfly. Below Sturgeon Falls Dam (Figure 9), there existed a dense growth of several types of aquatic vegetation including algal streamers that reached a length of 15 to 20 feet. The bottom organism population was composed principally of a large number of tolerant forms. Sensitive forms were much reduced when compared to the clean water station above the Kingsford-Iron Mountain sewage treatment plant. Very tolerant forms were increased. Samples collected about two miles above Kremlin Falls indicated similar degraded bottom conditions, however there was some reduction in tolerant forms and caddisflies made their first appearance below Niagara, indicating beginning stream recovery.

Figure 9. Populations of bottom organisms – upper Menominee River, August, 1963.



Slime bacteria or wood fibers were not observed in quiet water areas, however, small wood chips were noted. At County Trunk Z a bottom dwelling community was found that is considered normal for a healthy river environment.

Conservation officers report no fishing pressure in the area below Niagara, Wisconsin, because of the polluted condition of the river. Access areas, although limited in nature, are present but currently are not being used. The access area at Kremlin Falls, however, did appear to be used at the time of the biological investigation.

The discharge of large and small wood chips from paper pulp mill operations in Niagara interferes greatly with the normal uses of the bottom substratum by bottom dwelling organisms, fish, and other aquatic life. These chips, that eventually become water-logged and sink, destroy natural homes for bottom organisms, and also serve as a substrate for the development of slime bacteria which tend to mat together masses of wood chips, fibers, and other debris, which blanket the bottom in this area and cover up fish spawning areas. As the mat becomes more extensive, it collects gasses of decomposition which, on occasions, bring a mass of such material to the water surface where it is again broken up, dispersed, and often carried to a new location downstream. These solids, fibers, slimes, and floating septic sludge patches degraded the appearance of the river and reduced its aesthetic appeal for general recreational use.

The Upper Menominee River is degraded from the Kimberly-Clark Corporation paper mill at Niagara, Wisconsin to Kremlin Falls, a distance of 22 miles, by the presence of wood chips, wood fibers, and bacterial

slimes which cause a decrease in the population of sensitive bottom dwelling forms and a concurrent increase in the population of tolerant and very tolerant organisms. Return to a normal clean water bottom organism population occurs near County Trunk Z bridge, some 25 miles below the mill. Solids pollution damage to the Upper Menominee River is caused principally by wastes from the Kimberly-Clark Corporation.

Coliform Bacteria

According to water quality guides and objectives used by many state and interstate pollution control agencies, waters used for swimming and water contact sports should not average more than 1,000 MPN/100 ml total coliform bacteria and those used for general recreation should not average more than 5,000 MPN/100 ml.

For example, the Ohio River Valley Water Sanitation Commission, representing 8 states, and the Engineering Section of the Missouri Basin Health Council, representing 10 states, adopted the following guide for water pollution control activities:

> "For bathing or swimming waters, monthly arithmetical average 'most probable number' of coliform organisms should not exceed 1,000 per 100 ml during any month of the recreation season; nor exceed this number in more than 20 percent of the samples examined during any such month; nor exceed 2,400 per 100 ml on any day. For non-bathing or non-swimming waters, the monthly arithmetical average 'most probable number' of coliform organisms should not exceed 5,000 per 100 ml in any month of the recreational season, nor should exceed this number in more than 20 percent

of the samples examined during any such month."

Figure 10 shows the symmetrical mean total coliform and fecal coliform densities in the Upper Menominee River during the August, 1963 survey. The symmetrical mean total coliform density, determined by plotting all total coliform tests from each station on probability paper, is the value that was equalled or exceeded 50 percent of the time.

Total coliform densities increased from 340 MPN/100 ml above Iron Mountain-Kingsford (M-96.4) to 900 MPN/100 ml at the U. S. Highway 2 bridge (M-91.8), some 4-1/2 miles below the treatment plant outfall. Fecal coliform concentrations increased from 21 to 60 in this same reach. Bacterial quality of the Menominee River below the Iron Mountain-Kingsford sewage treatment plant is satisfactory for swimming and general recreational use.

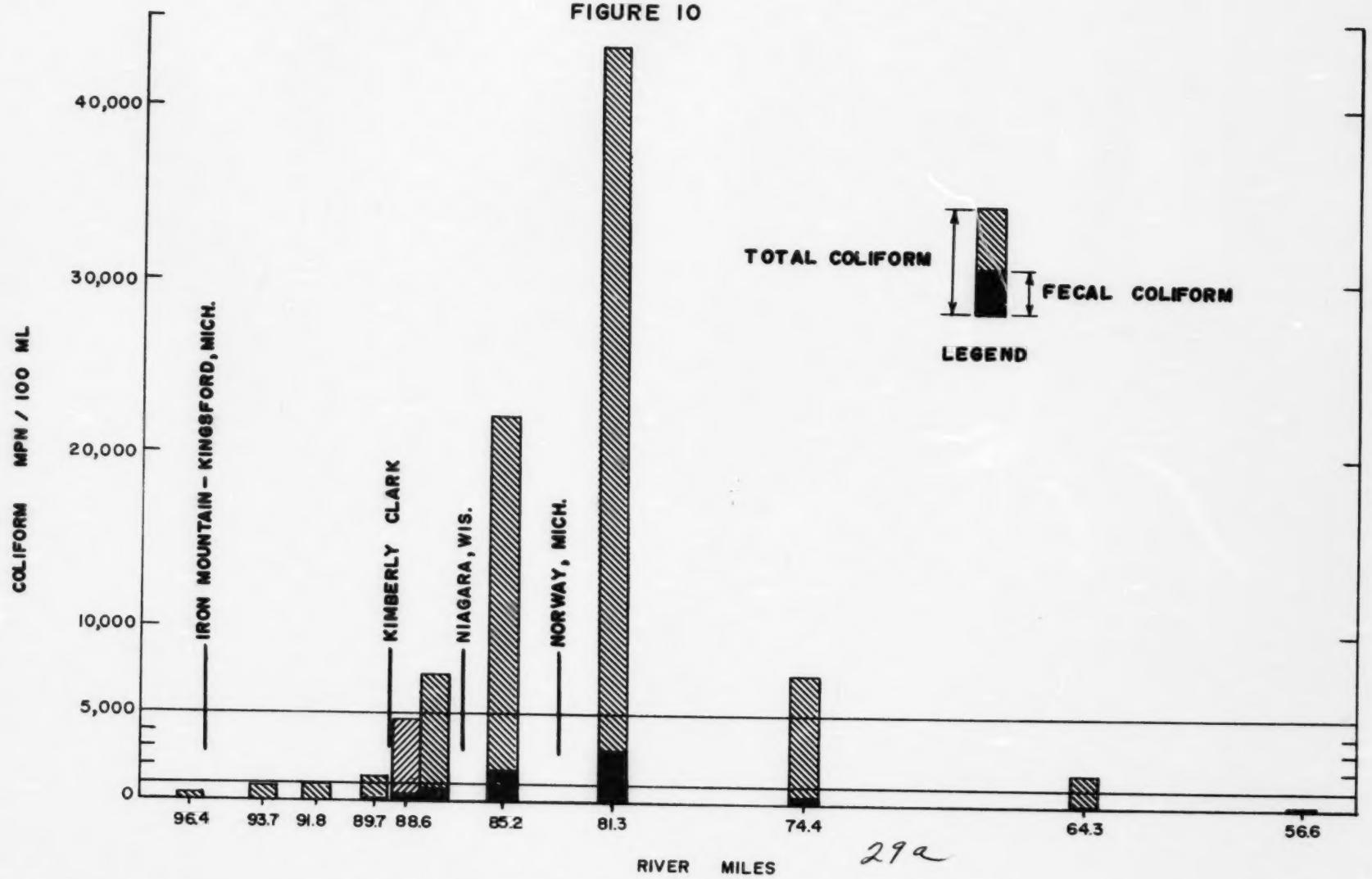
A local sewer, at the Highway 2 bridge, and a flume from the pulp mill hot pond enter the river above the power plant intake at the Kimberly-Clark power dam in Niagara, Wisconsin (M-89.7) where the total coliform densities increased to 1390 and fecal coliform densities increased to 97.

About one mile below the Kimberly-Clark mill (M-88.6), but above the outfall from the Niagara, Wisconsin sewage treatment plant, the total coliform densities increased to 4600 on the Michigan side and 7300 on the Wisconsin side of the river, and the fecal coliform densities increased to 195 and 870 at these two sampling points. This significant increase, especially in the fecal coliform count, indicates that some domestic sewage may bypass the municipal sewers and enter the river directly. This possibility should be investigated during a subsequent

COLIFORM BACTERIA

UPPER MENOMINEE RIVER

FIGURE 10



detailed sanitary survey of the area.

At the U. S. Highway 8 bridge (85.2), about three miles below the Niagara treatment plant outfall, wastes are mixed throughout the Michigan and Wisconsin waters of the entire stream cross section and the mean total coliform density increased to 22,100 and the fecal coliform density increased to 1,890 MPN/100 ml.

Untreated sewage from Norway, Michigan is discharged into Sewer Creek about 2.4 miles above its confluence with the Menominee River. Sewer Creek, entering the Menominee River about two miles below the previous sampling station at the U. S. Highway 8 bridge, contained approximately 415,000 MPN/100 ml total coliform and 120,000 MPN/100 ml fecal coliform 0.6 miles above its mouth.

The symmetrical mean bacterial densities in the Menominee River increased to 43,500 total coliforms per 100 ml and 3000 fecal coliforms per 100 ml in the pool above the Norway power dam (M-81.3), which is located about seven miles below Niagara and two miles below the entrance of Sewer Creek. At this station the arithmetic average of total and fecal coliform densities were 70,200 and 5,100 MPN/100 ml respectively.

The Faithorn, Michigan sampling station (M-74.4) is fourteen miles below Niagara and nine miles below Sewer Creek. Mean total coliform density at this station had declined to 7,300 per 100 ml and fecal coliforms had declined to 370 per 100 ml. Downstream from this point, the mean total coliform density declined to 1,900 per 100 ml at County Trunk Z (M-64.3) and to 130 per 100 ml at Chalk Hill Dam (M-56.6). Fecal coliform densities declined to 86 per 100 ml and less than 20 per

100 ml respectively, at these last two named stations.

Bacterial pollution, principally from Niagara, Wisconsin and Norway, Michigan, increased coliform densities above the 5,000 MPN/100 ml level considered satisfactory for general recreational water use for a distance of 14 miles below Niagara and 9 miles below Sewer Creek. For a distance of 24 miles below Niagara and 19 miles below Sewer Creek, total coliform densities exceeded the 1,000 MPN/100 ml level considered satisfactory for water contact sports. The proportionate load from each of these sources has not been determined.

pH, Turbidity and Color

The waste discharges did not significantly alter river water characteristics measured by pH, turbidity and color.

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LOWER MENOMINEE RIVER

SOURCES OF WASTES

Pulp and paper mill wastes and treated domestic sewage are discharged to the Lower Menominee in the Marinette, Wisconsin and Menominee, Michigan area. Wastes from the Ansul Chemical Corporation in Marinette, Wisconsin, which created problems in former years, no longer pollute the river. Location of the waste discharges and the estimated organic and solids loads are shown on Figure 11 and Table 3.

As shown on Figure 12, 81 percent of the organic waste (5-Day BOD) is discharged by the Scott Pulp and Paper mill in Marinette and 10 percent by the Marathon Division of American Can Company in Menominee. The other 9 percent represents the combined discharges from the Scott groundwood mill in Menominee and the Menominee, Michigan and Marinette, Wisconsin sewage treatment plants. Of the total 244,500 PE, 197,000 are discharged by the Scott Mill in Marinette and 25,500 from the Marathon mill in Menominee.

As shown in Figure 13, 91 percent of the solids are discharged by the pulp and paper mills and the remaining 9 percent by the sewage treatment plants. Of the 9.0 tonsper day total approximately 2.5 tons of volatile suspended solids per day, or 28 percent, came from the Marathon paper mill, 3-1/2 tons or 39 percent, from the Scott mill in Marinette, and 2.2 tons per day or 24 percent of the total from the Scott Paper Company groundwood mill in Menominee.

EFFECTS ON WATER QUALITY

5-day Biochemical Oxygen Demand(BOD)

BODs in the impoundment above the upper dam (M-3.52) averaged 1.1 mg/l. The BOD increased to 5.3 at the Hattie Street bridge (M-2.29) below the Scott mills and averaged 5.1 below the sewage treatment plants (M-0.75). An average of 4.7 was observed in the channel at the mouth of the river below Marathon (M-0.15) and the (REFER TO TEXT FROM HERE ON)

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TABLE 3

SOURCES OF WASTES

Estimated Net Loads to Lower Menominee River

August, 1963

SOURCE	ORGANIC WASTES (5 Day BOD)		SOLIDS WASTES (Vol. Susp. Solids)	
	Population Equivalents	% of Total	Tons/ Day	% of Total
SCOTT PAPER CO.(1) Marinette, Wisconsin (Fiber recovery, hauling for road binder)	197,000	80.6	3.5	38.9
MARINETTE, WISCONSIN(2) Municipal and Industrial Wastes (Primary Treatment single stage chlorination)	10,000	4.1	0.5	5.6
MENOMINEE, MICHIGAN(3) (Primary Treatment, with pre- and postchlorination)	7,300	3.0	0.3	3.3
SCOTT PAPER CO.(4) Menominee, Michigan (Fiber recovery)	4,700	1.9	2.2	24.4
AMERICAN CAN CO.(4) Marathon Div. - Paper Menominee, Michigan (Fiber recovery)	25,500	10.4	2.5	27.8
TOTAL -	244,500	100.0	9.0	100.0

(1) Calculated from production figures from Scott and unit loss value from Wisconsin survey data.
(2) P.E. from 1963 rough draft for Revised 1960 Summary Report. Solids calculated from P.E. estimates and avg. reductions.
(3) P.E. from 1963 rough draft for Revised 1960 Summary Report. Solids from plant data.
(4) Calculated from production figures from Scott and American Can; and unit losses from Michigan 1963 surveys.

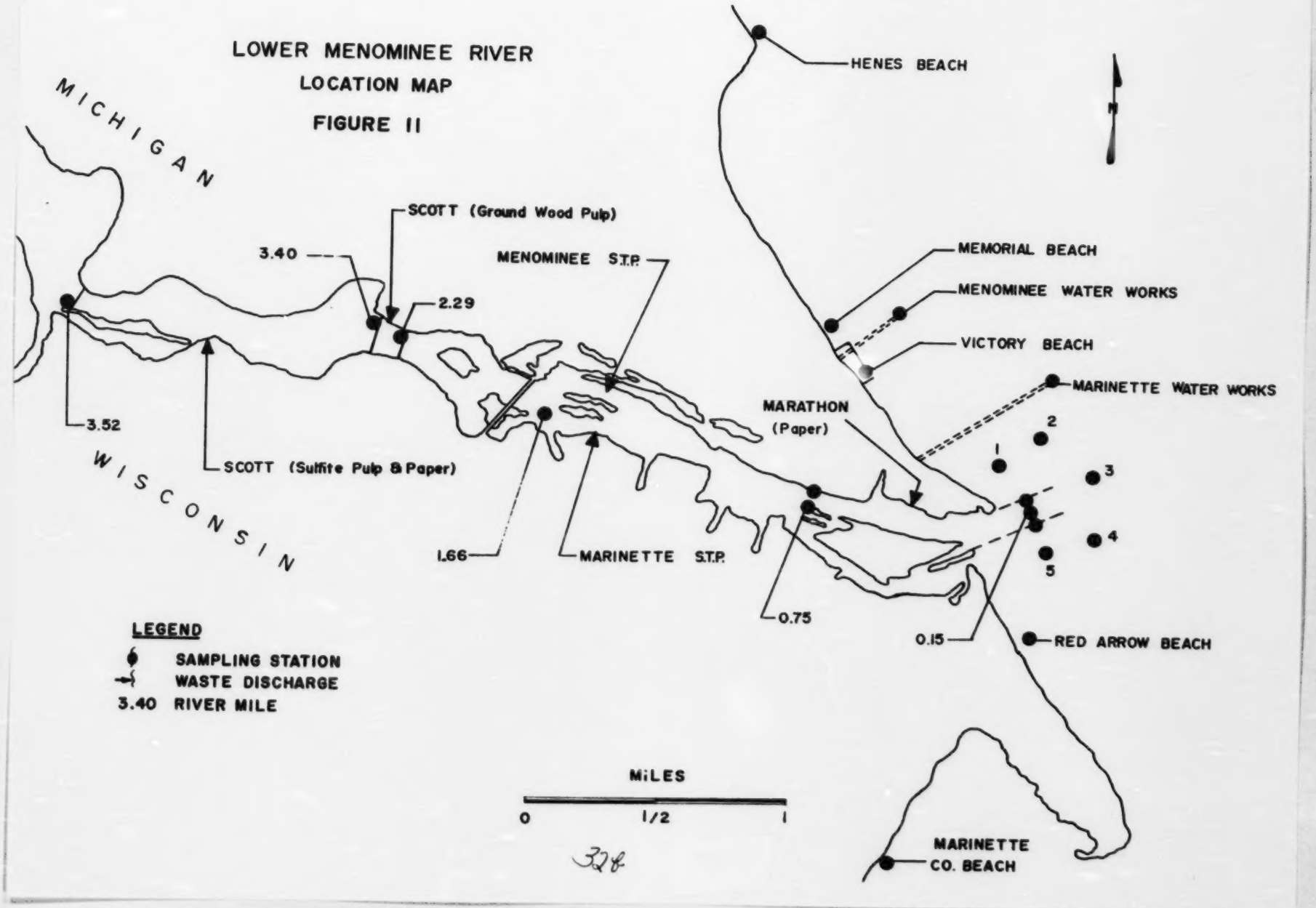
LOWER MENOMINEE RIVER
LOCATION MAP
FIGURE II
MICHIGAN
WISCONSIN
HENES BEACH
N
SCOTT (Ground Wood Pulp)
3.40
MENOMINEE S.T.P.
2.29
MEMORIAL BEACH
MENOMINEE WATER WORKS
VICTORY BEACH
MARINETTE WATER WORKS
MARATHON
(Paper)
3.52
SCOTT (Sulfite Pulp & Paper)
1.66
MARINETTE S.T.P.
0.75
0.15
RED ARROW BEACH
1
2
3
4
5
LEGEND
SAMPLING STATION
WASTE DISCHARGE
3.40 RIVER MILE
MILES
0
1/2
1
MARINETTE
CO. BEACH

TABLE 3

SOURCES OF WASTES

Estimated Net Loads to Lower Menominee River

August, 1963

SOURCE	ORGANIC WASTES (5-Day BOD)		SOLIDS WASTES (Vol. Susp. Solids)	
	Population Equivalents	% of Total	Tons/ Day	% of Total
SCOTT PAPER CO.(1) Marinette, Wisconsin (Fiber recovery, hauling for road binder)	197,000	74.6	3.5	27.3
MARINETTE, WISCONSIN(2) Municipal and Industrial Wastes (Primary Treatment single stage chlorination)	10,000	3.8	0.5	3.9
MENOMINEE, MICHIGAN(3) (Primary Treatment, with pre- and postchlorination)	7,300	2.8	0.3	2.4
SCOTT PAPER CO.(4) Menominee, Michigan (Fiber recovery)	4,700	1.8	2.2	17.2
AMERICAN CAN CO.(4) Marathon Div. - Paper Menominee, Michigan (Fiber recovery)	44,600	17.0	6.3	49.2
TOTAL -	263,600	100.0	12.8	100.0

(1) Calculated from production figures from Scott and unit loss value from Wisconsin survey data.

(2) P.E. from 1963 rough draft for Revised 1960 Summary Report. Solids calculated from P.E. estimates and avg. reductions.

(3) P.E. from 1963 rough draft for Revised 1960 Summary Report. Solids from plant data.

(4) Calculated from production figures from Scott and American Can; and unit losses from Michigan 1963 surveys.

SOURCES OF WASTES
B.O.D. POPULATION EQUIVALENTS
LOWER MENOMINEE RIVER
FIGURE 12

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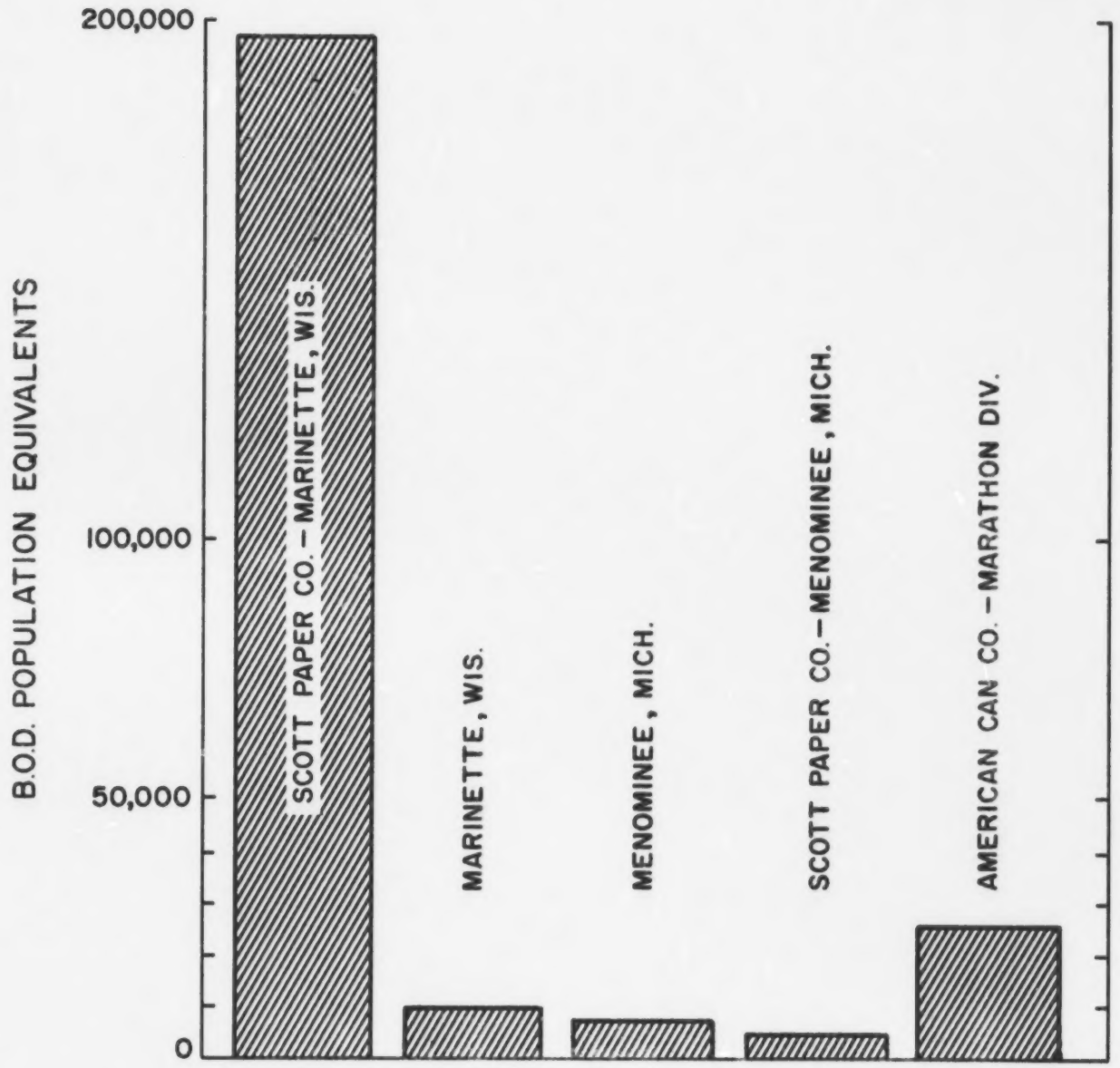

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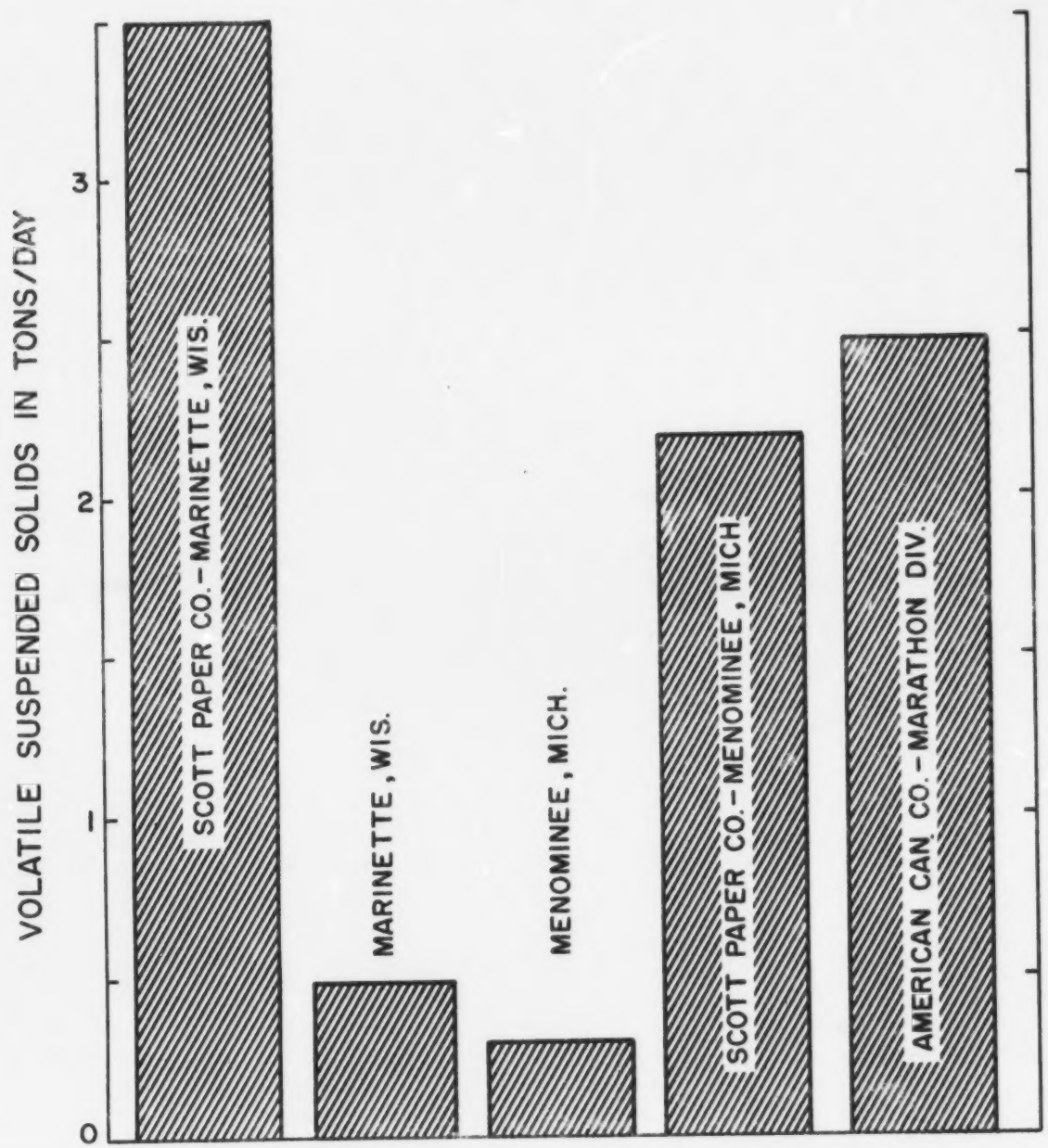
SOURCES OF WASTES
VOLATILE SUSPENDED SOLIDS
LOWER MENOMINEE RIVER
FIGURE 13



EFFECTS ON WATER QUALITY

5-day Biochemical Oxygen Demand (BOD)

BODs in the impoundment above the upper dam (M-3.52) averaged 1.1 mg/l. The BOD increased to 5.3 at the Hattie Street bridge (M-2.29) below the Scott mills and averaged 5.1 below the sewage treatment plants (M-0.75). An average of 4.7 was observed in the channel at the mouth of the river below Marathon (M-0.15) and the BODs ranged from 1.1 to 1.7 in the five stations in Green Bay.

Dissolved Oxygen (DO)

The average dissolved oxygen concentrations in the Lower Menominee River are shown on Figure 14. The dissolved oxygen averaged 6.7 above the waste sources (M-3.52), 5.8 below the Scott mills (M-1.66), 5.0 below the sewage treatment plants (M-0.75), and 4.4 below the Marathon paper mill (M-0.15), and ranged from 8.1 to 9.0 in the five stations in Green Bay. The minimum values were 3.6 between the sewage treatment plants and the Marathon mill, and 3.4 in the channel at the mouth below the Marathon mill.

The organic waste loadings to the lower Menominee River depressed the average dissolved oxygen concentrations below 5.0 mg/l near the mouth of the river, but the minimum dissolved oxygen concentrations remained above the 3 mg/l level considered critical to fish life by the State of Wisconsin.

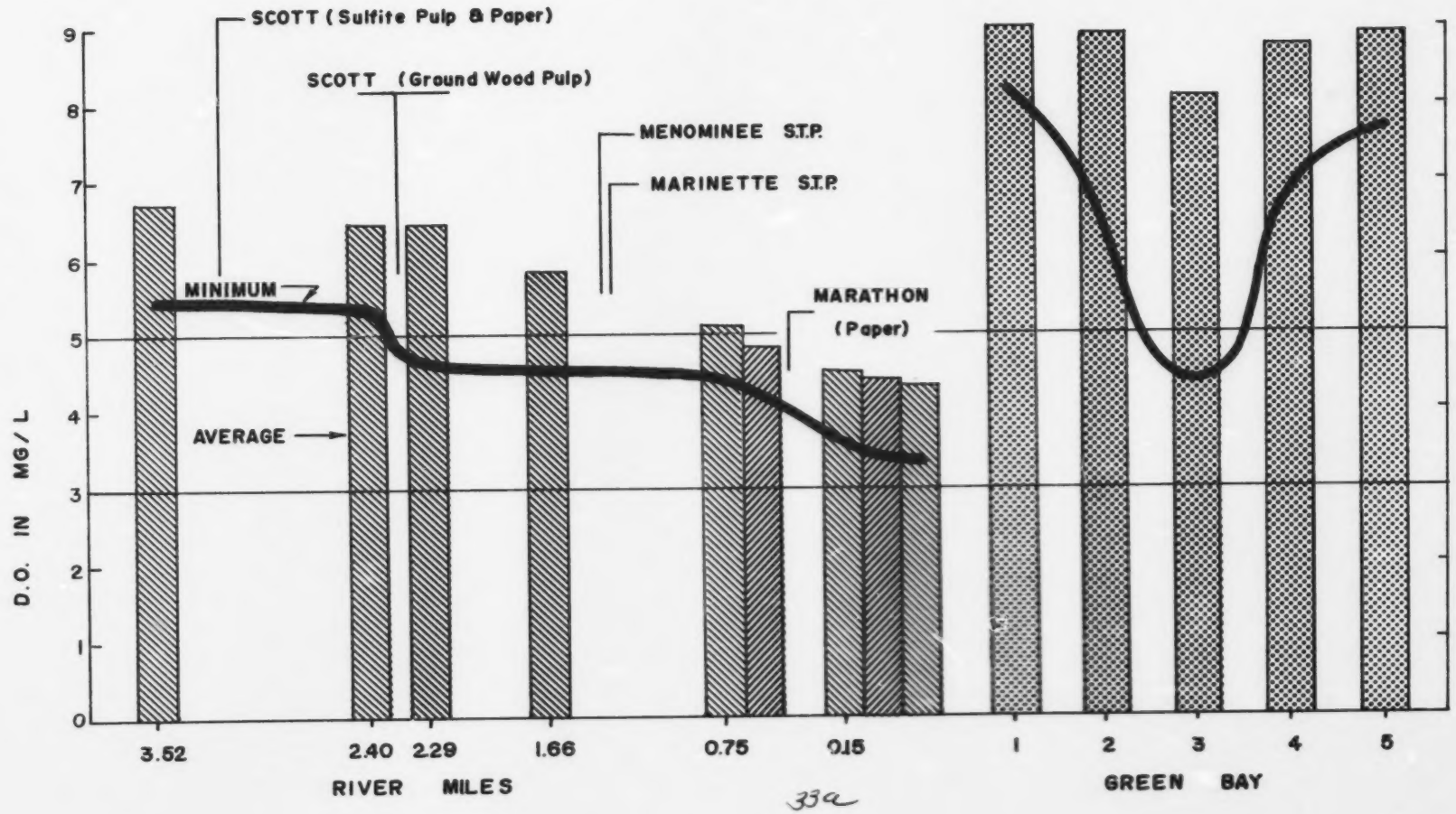
Arsenic and Chlorides

River waters were analyzed for arsenic and for chlorides to evaluate the effects of wastes discharged from the Ansul Chemical Company.

DISSOLVED OXYGEN

LOWER MENOMINEE RIVER

FIGURE 14



River samples, collected both above and below the chemical company waste discharge contained from 2 to 5 mg/l of chlorides, and less than .001 mg/l of arsenic. The survey data did not indicate pollution of the Lower Menominee River by wastes from the Ansul Chemical Company.

pH, Alkalinity, Hardness, and Color

The waste discharges did not significantly alter river water characteristics measured by pH, alkalinity, hardness, and color.

Total Suspended Solids

Average suspended solids concentrations in the river increased from 6.1 mg/l above the upper dam (M-3.52) to 8.9 mg/l at the Hattie Street bridge (M-2.29) below the Scott mills. Samples collected from the station between the sewage treatment plants and the Marathon paper mill (M-1.66) averaged 4.75 and increased to 5.3 at the mouth below the Marathon mill (M-0.15). Except for a 6.2 value at the northeasterly sampling station, samples collected from 4 out of 5 of the Green Bay stations averaged 3.3 mg/l.

The above averages represent 26 samples collected twice daily at each station. On Wednesday, August 8th, 1963, the morning and noon samples from each of the two sample stations (M-2.29 and M-1.66) located between the Scott groundwood mill and the sewage plant outfalls increased sharply to 40 mg/l suspended solids in the morning and 25 mg/l about noon.

Coliform Bacteria

The symmetrical mean total coliform densities (Figure 15) increased from 400 MPN/100 ml above the upper dam (M-3.52) to 2000 at the Hattie Street bridge (M-2.29) below the Scott paper mills and 2600 in the river above the sewage treatment plant outfalls (M-1.66). Total coliform densities increased to 6000 MPN/100 ml in the reach between the treatment plant outfalls and the Marathon paper mill (M-0.75). In the channel at the mouth of the river (M-0.15), the symmetrical mean increased to 8500 MPN/100 ml and the arithmetic average was 15,200 MPN/100 ml.

Effluent from the Menominee, Michigan sewage treatment plant contained about 900 total coliform/100 ml. Effluent from the Marinette, Wisconsin sewage treatment plant enters the river through two outfalls which contained 7600 and 260,000 coliforms per 100 ml respectively.

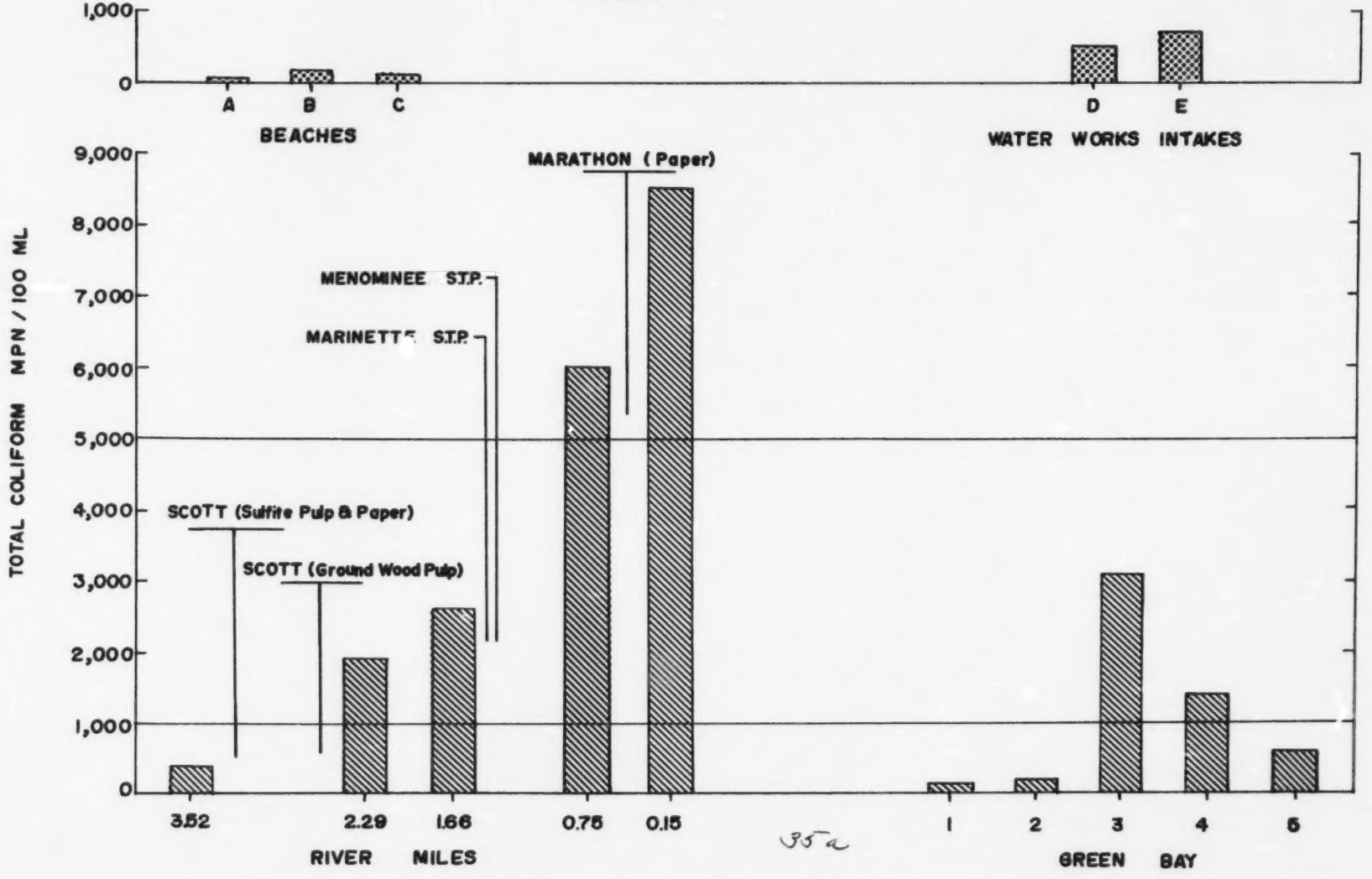
Total symmetrical mean coliform densities in the river below the sewage treatment plant outfalls increased slightly above the 5000 MPN/100 ml level considered satisfactory for general recreational use. The survey data indicated that the effluents from the Marinette, Wisconsin sewage treatment plant were the principal sources of bacterial pollution.

As shown on Figure 15, the symmetrical mean coliform density in the Green Bay stations clustered around the river mouth, amounted to 3000 MPN/100 ml at the station just outside the mouth and 1400 and 600 MPN/100 ml at the two southerly sampling stations. The coliform densities were 175 and 138 respectively at the two northerly sampling stations.

COLIFORM BACTERIA

LOWER MENOMINEE RIVER

FIGURE 15



Symmetrical mean coliform densities at the two municipal water works intakes and the five municipal swimming beaches ranged from about 70 to 700 MPN/100 ml. Bacterial pollution of the Lower Menominee River is reduced by dilution and natural purification as these waters flow into Green Bay. Water quality, as measured by the coliform tests, was satisfactory at the bathing beaches and the water works intakes in Green Bay during the survey.

BIOLOGY

Past Studies

The 1961 Wisconsin report states that the bottom biota was normal for the physical conditions encountered above the upper dam in Marinette. Polluted conditions were found below the interstate Highway 41 bridge with wood fibers, wood chips, and slime bacteria covering the bottom deposits. Near Ansul Chemical Company, bottom conditions were degraded to such an extent that no biota were encountered in the samples collected. Long wood fibers, bark, and slime bacteria were found intermingled in the bottom sludge and deposited over those areas of natural sand bottom.

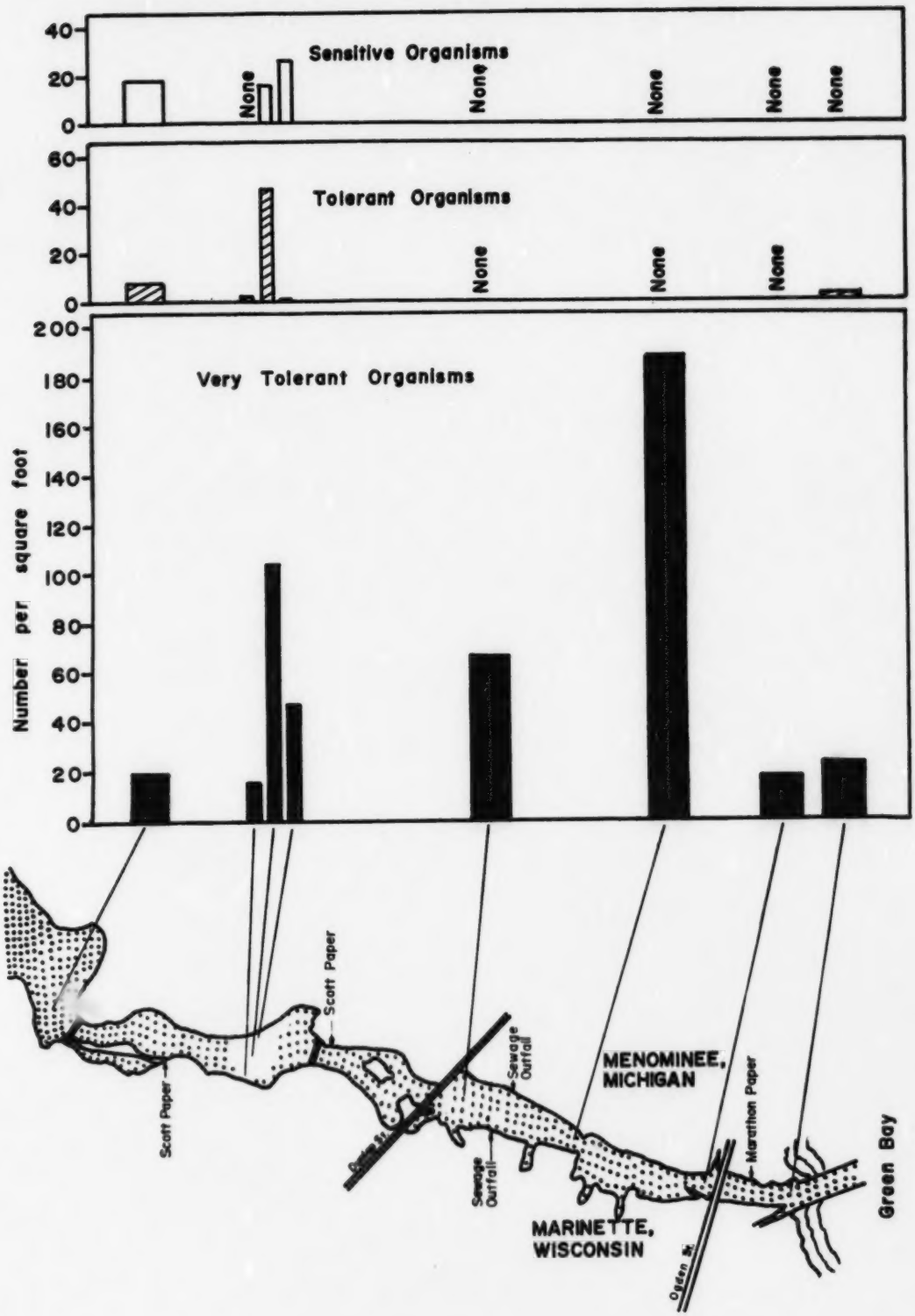
A report by the Michigan Water Resources Commission, dated August 24, 1961, discusses fish taste tests performed on Menominee River fish in the region of Menominee-Marinette. Of six Menominee River walleyes tasted, one was judged as good, two as fairly good, one just acceptable, and two as non-acceptable. Conservation officers in both Michigan and Wisconsin indicate that complaints have been received on off-flavor in fish caught from the Lower Menominee River in the reach polluted with paper mill effluent.

Current Biological Data

Bottom samples on the Lower Menominee River, in the vicinity of Menominee, Michigan - Marinette, Wisconsin, were taken from just above the upper dam to the mouth of the river (Figure 16). A bottom dwelling community normally associated with an unpolluted flowage habitat was found at the upstream sampling site. Below the Scott Paper Company, Marinette, Wisconsin, but above the lower dam, samples across the river showed a drastic change in bottom life between the Wisconsin side, receiving effluent from the mill, and the Michigan side. On the Wisconsin side, accumulated sludge deposits were composed of wood chips, fibers, and slime bacteria. On occasion, masses of this material would boil to the surface of the water, create unsightly conditions, gradually disperse, and float downstream to reform a sludge deposit. Bottom dwelling organisms were limited only to very tolerant forms, and because of adverse bottom conditions, these occurred in small numbers, indicating very polluted conditions. Near the center of the river very tolerant sludgeworms and midges attained high populations, but at the same time, sensitive burrowing mayflies were able to exist in a population of 15 per square foot. This zone of the river may be termed moderately polluted. On the Michigan side of the river, the bottom organisms population was quite similar to that encountered above the upper dam - a clean water area.

Below the lower dam, bottom samples indicated mixing of the mill wastes across the river, in both Michigan and Wisconsin waters. Wood fibers and slime bacteria were found intermingled with bottom

Figure 16. Populations of bottom organisms—
lower Menominee River, August, 1963.



deposits to the river's mouth. Only very tolerant organisms were able to survive severely degraded bottom conditions in this environment. The population of these was increased below the sewage treatment plant outfalls, because of the increased food supply, and diminished near the mouth of the river because of septic bottom conditions. Samples below Marathon Paper Company revealed extensive sludge deposits and few organisms because of severely polluted conditions. Floating solids were present. On the Wisconsin side at this point the sludge had a strong hydrogen sulfide odor and contained yellow particles of elemental sulphur. A sulphur pile was noted on the docks upstream.

The Menominee River is degraded below the Scott Paper Company at Marinette, Wisconsin to its mouth, a distance of three miles, as indicated by the presence of wood chips, wood fibers, and slime bacteria, and the elimination of sensitive bottom dwelling organisms. Near the river's mouth, bottom conditions were so polluted that only a few organisms of any type could survive. Fish food has been eliminated.

Marina operators reported that solids and slimes in the river foul motor boat cooling systems. Suspended solids, fibers, bacterial slimes and patches of floating septic sludge degraded the appearance of the river and reduced the aesthetic appeal of the Lower Menominee River for general recreational use.

BRULE RIVER

SOURCES OF WASTES

Throughout a distance of about 10 miles from the mouth, drainage from four iron mines and the effluents from four municipal sewage treatment plants enter the Iron River and flow southeasterly into the interstate waters of the Brule River. A fifth municipal sewage treatment plant discharges near the mouth of the Brule. Location of the waste discharges and the estimated waste loads are shown on Figure 17 and Table 4.

EFFECTS ON WATER QUALITY

Iron

Gross pollution of the Iron and Brule River by acid mine drainage from the Homer-Wauseca Mines in 1962 has been corrected.

Although the severe damaging effects of 1962 have been minimized, the August 1963 waste discharges from the four mines still caused some turbidity in the stream. Turbidity of the upper Brule above Iron River (B-32.4) never exceeded 5 units. Turbidity in the mouth of the Iron River ranged from 20 to 50 for an average of 36. For a distance of 22 miles below this point the turbidity of the Brule River ranged from 14 to 18 units. After settling in the Brule Island Dam impoundment (B-1.7), turbidities again fell to 5 units.

This moderate increase in the turbidity and iron content of the Brule River was caused by iron bearing acid mine drainage from the

BRULE RIVER

LOCATION MAP

FIGURE 17

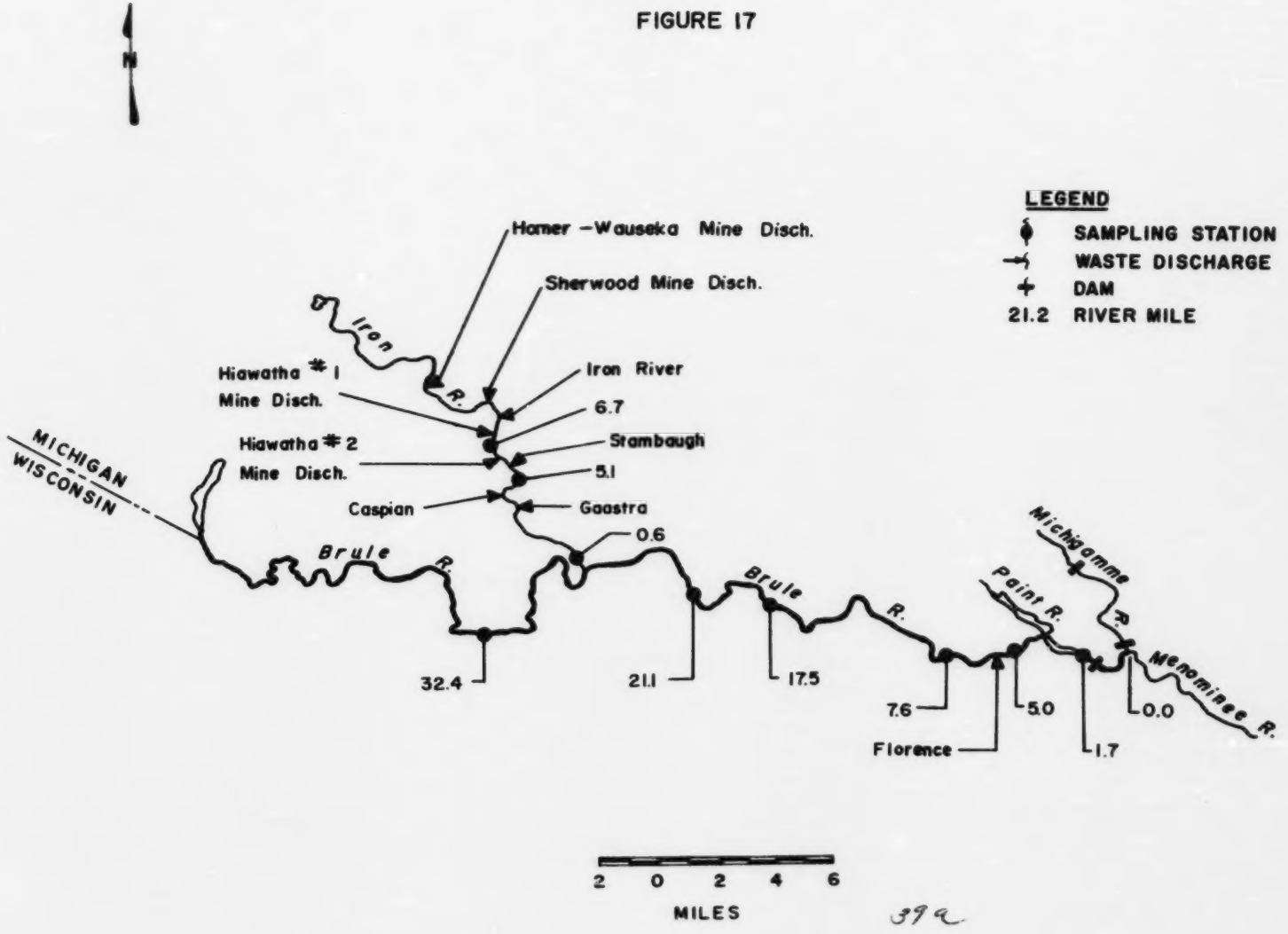


TABLE 4

SOURCES OF WASTES

Estimated Loads to the Tributaries of the Brule River

August, 1963

SOURCE	ORGANIC WASTES (5-Day BOD) Population Equivalents	% of Total
DOMESTIC WASTES		
Iron River, Michigan[1] (Primary Treatment with chlorination)	1,400	42
Stambaugh, Michigan[1] (Secondary Treatment with chlorination)	140	4
Caspian, Michigan[2] (Primary Treatment - Imhoff Tank)	1,040	31
Gaastra, Michigan[2] (Primary Treatment - Septic Tanks)	465	14
Florence, Wisconsin[2] Domestic + Cheese Plant Wastes. (Secondary Treatment - Stabilization Pond)	300	9
	3,345	100
IRON MINE DEWATERING[3]		
Homer-Wauseca Mine	-	-
Sherwood Mine	-	-
Hiawatha #1 Mine	-	-
Hiawatha #2 Mine	-	-

(1) Data from Aug. of 1962 Sewage Treatment Plant Reports.
(2) P.E. from 1963 rough draft for Revised 1960 Summary Report.
(3) Acid Iron-Bearing Mine Wastes cannot be equated in terms of BOD Population Equivalents. Amount of Iron and Acid not measured at Source.

Homer-Wauseca, Sherwood, Hiawatha #1 and Hiawatha #2 mines discharged into the Iron River. Efforts to reduce the amount of iron and turbidity introduced into the Brule River from these sources should be continued.

Dissolved Oxygen (DO)

The average dissolved oxygen concentration of the Brule River ranged from 8 to 10 mg/l. These high dissolved oxygen values show that neither the organic content of the treated sewage nor the ferrous iron of the mine wastes caused excessive oxygen depletion.

Coliform Bacteria

The symmetrical mean total coliform and fecal coliform densities in the Brule River during the August, 1963 survey are shown on Figure 18.

Six miles above the mouth of the Iron River (B-32.4), the Brule River contained a symmetrical mean density of 395 MPN/100 ml total coliforms and 55 MPN/100 ml fecal coliforms.

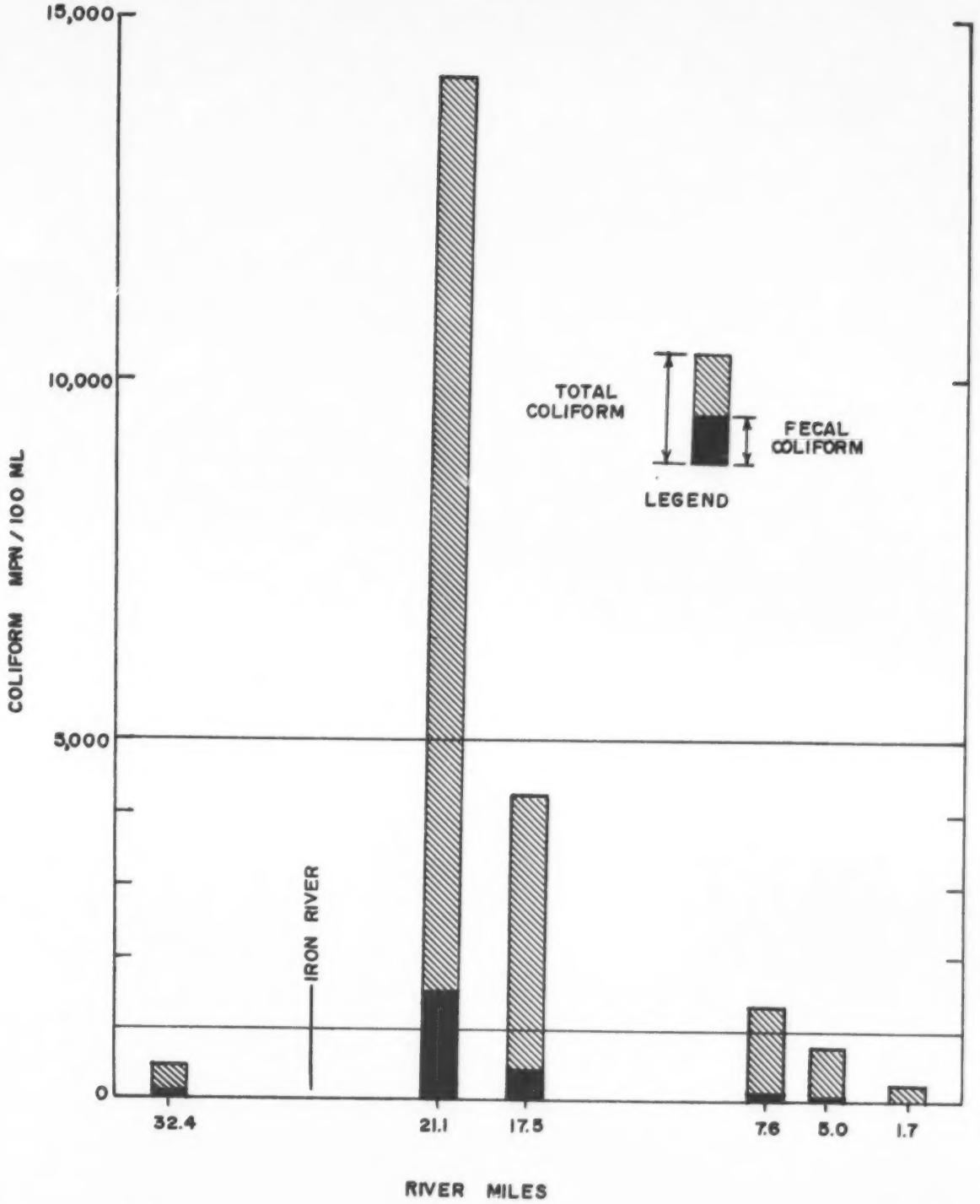
Four communities, namely, Iron River, Stambaugh, Caspian and Gaastra, discharge sewage, after varying degrees of treatment, to the Iron River in the reach from 5 to 8 miles above its junction with the Brule River. The Iron River contained 47,500 MPN/100 ml total coliforms and 7,900 MPN/100 ml fecal coliforms at the sampling station 0.6 miles above its junction with the Brule River. At this station, the arithmetic average total and fecal coliform densities amounted to 89,900 and 10,320 MPN/100 ml respectively. The proportionate amount of this coliform load discharged by each one of these four communities was not determined.

Maximum bacterial pollution in the Brule River was observed at

COLIFORM BACTERIA

BRULE RIVER

FIGURE 18



river mile 21.1, some 5 miles below the mouth of the Iron River, where the symmetrical mean total coliform density increased to 14,200 and the fecal coliform increased to 1,500 MPN/100 ml. At this station the arithmetic average total and fecal coliform densities were 18,230 and 1,920 MPN/100 ml respectively.

Nine miles below the Iron River (B-17.5), the total coliform density decreased to 4,250 and the fecal coliform density decreased to 430. At this station, and downstream, the coliform densities were below the level considered satisfactory for general recreational use. Twenty-two miles below the junction with Iron River (B-5.0), the total coliform density decreased to 720 which meets the bacterial objective for swimming water quality.

The survey data, illustrated on Figure 18, show that bacterial discharges into the Iron River increased the symmetrical mean coliform densities in the Brule River materially above the 5,000 level considered satisfactory for general recreational purposes, and polluted the interstate waters of the Brule River for a distance of more than five and most probably about eight miles.

A more detailed survey of this local area, including bacteriological analysis of the sewage discharges and purification efficiencies at the treatment plants, should be conducted to establish the proportionate amount of bacterial pollution from each of these four sources and the treatment modifications that may be necessary to safeguard the recreational value of the Brule River.

Biology

The population of bottom dwelling organisms was investigated on the Iron and Brule Rivers during August 7-8, 1963. At all selected stations the substratum was rock, rubble, and gravel with occasional patches of sand. The current was swift and the water depth ranged from 6 inches to 2 feet in most areas sampled.

Biological investigation of the Iron River extended from the U. S. Forest Service Road 137 above the entrance of mine drainage, down to its junction with the Brule River. At the upstream station, brook trout were noted in the pool areas, several kinds of higher aquatic plants were abundant, fresh water sponge was growing on many of the rocks, and bottom organisms were composed of those groups normally associated with clean water.

Below Sunset Creek, which carries the Homer-Wauseca mine drainage into the Iron River, a dense floc existed in the quiet water areas while the bottom beneath the swifter water was cemented by the iron deposits, thus eliminating the many living spaces normally inhabited by stream organisms. A tremendous upsurge in the growth of a filamentous green algae produced a drastic change in the population structure of bottom organisms. The population of some types, living in close association with the dense algal growth, increased tremendously. Other forms that strain their food from the water as it passes over riffle areas were practically eliminated.

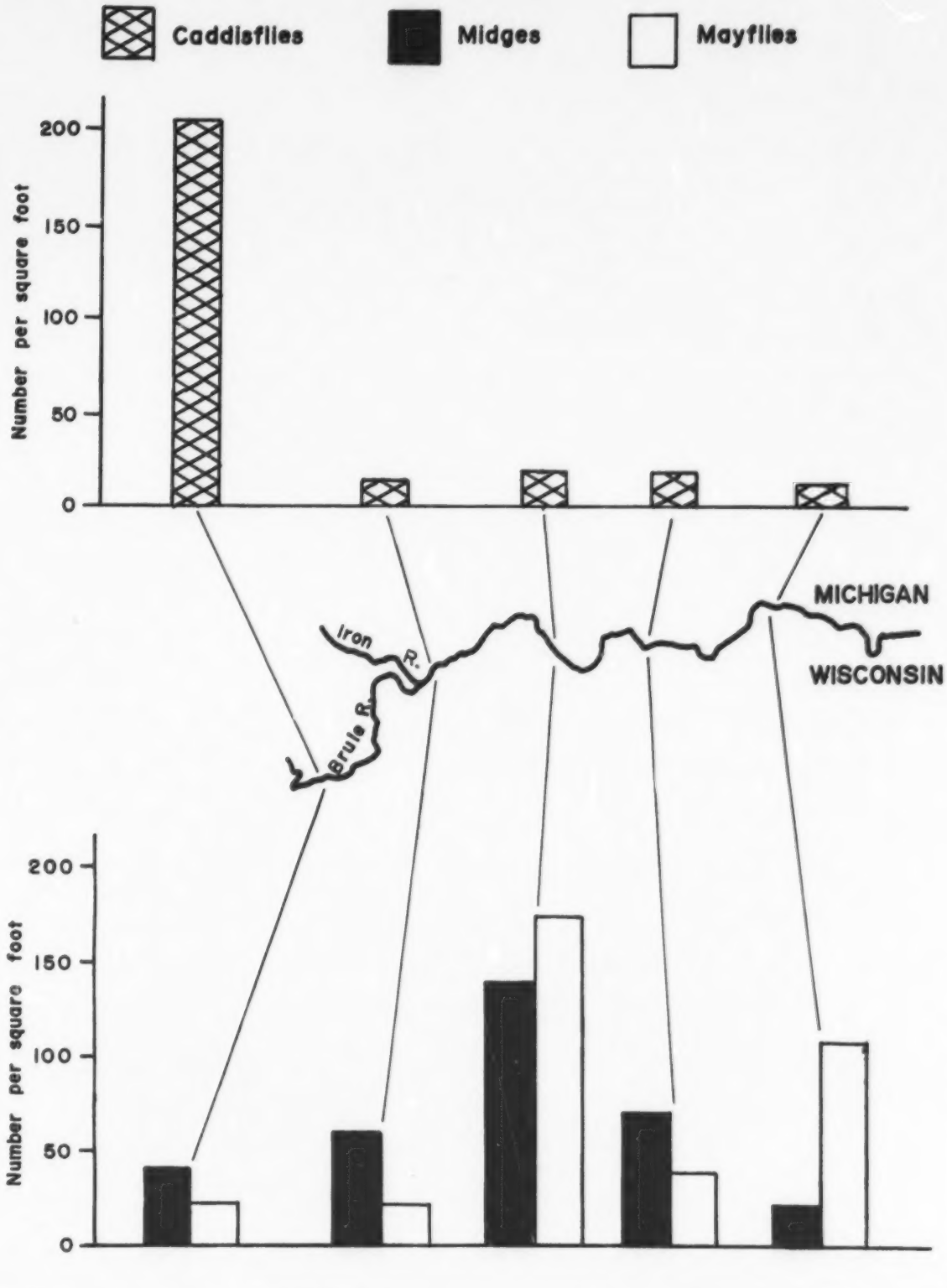
Just south of Caspian, Michigan, and again just above the junction of the Iron River with the Brule, the cementing of the rock, rubble, and

gravel substratum was more pronounced; the hard deposit varied in thickness up to 3/8 inches. The filamentous green algae was abundant, and the population of bottom organisms was very low. A total of 438 organisms per square foot was found at the station above Sunset Creek, compared to only seven organisms per square foot in the Iron River just above its confluence with the Brule, indicating a severely degraded bottom environment at the latter station.

Benthic samples on the Brule River were collected from the Wisconsin 139 - Michigan 189 bridge, above Iron River, to just above McGovern's Creek some 20 miles downstream. Bottom organism populations typically associated with clean water and including an abundance of insect larva, such as stoneflies, riffle beetles, mayflies, and caddisflies, were found above the confluence with the Iron River.

Eight-tenths of a mile below the confluence, the benthic population in the Brule River was severely altered. At this and other downstream stations on the Brule, the population of many sensitive forms commonly associated with clean water was drastically reduced. A typical example is shown in graphing the caddisfly population at selected stations (Figure 19). Riffle beetles and stoneflies closely follow the same pattern as shown by the caddisflies. The opposite effect is shown by those organisms that are able to secure their food supply while living in close association with a dense growth of filamentous green algae. The midges and mayflies (Figure 19) show a population increase at those sampling sites in which filamentous green algae are abundant. At the last station sampled, just above McGovern's Creek, clean water associated stoneflies and mayflies were abundant. The midge

Figure 19. Populations of selected bottom organisms - Brule River, August, 1963.



population was much reduced compared to the past two stations because of decreased algal growth and an increase in predators, but two groups, the clean water associated caddisflies and riffle beetles, had not attained the populations displayed at the stations above the confluence with the Iron River.

The biological investigations revealed that the bottom of the Iron River is severely degraded from Sunset Creek to its mouth; and during the survey supported a very small population of bottom organisms in its lower reach. The bottom of the Brule River is degraded throughout a distance of approximately 14 miles below the Iron River.

Those organisms that are reduced in population in the Brule River, below its confluence with the Iron, normally serve as an excellent source of fish food. The reduction in the fish food supply, and the cementing - by iron deposit - of gravel areas which will interfere with fish spawning, will serve to reduce the expected fish population within the affected areas.

The effect of the iron deposit on aquatic life in the Iron and Brule Rivers will be evident until the cementing of the rocks and rubble is broken down and natural living spaces for organisms are restored. Further investigations will be needed to determine if the present condition is a result of mine water pumped prior to February, 1963, or of current mine activity.